THE BULLETIN
February 79 $2

Energy and ethics
U.S. foreign arms sales
Nuclear remains in the Pacific

THE BULLETIN
OF THE ATOMIC SCIENTISTS

a magazine
of science &
public affairs

Carl von Ossietzky
1935 Nobel Peace
Laureate

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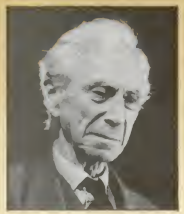
A HISTORIC APPEAL

Just before his death, twenty-three years ago, Albert Einstein along with Bertrand Russell, issued an appeal, raising his voice on an issue that has become more urgent since his death.

Einstein and Russell outlined the inevitable horrors that would follow the use of nuclear weapons. Then they said:



Here then, is the problem which we present to you, stark and dreadful and inescapable: Shall we put an end to the human race; or shall mankind renounce war?

Most of us are not neutral in feeling, but, as human beings we have to remember that, if the issues between East and West are to be decided in any manner that can give any possible satisfaction to anybody, whether Asian or European or American, whether white or black, then these issues must not be decided by War. We should wish this to be understood, both in the East and West. *From the Einstein-Russell Manifesto.*

In the time that has passed since ***this historic appeal*** *many other issues have gripped the* ***attentions of thinking*** *men and women. But there* ***is none so urgent, none so*** *pressing as this one:* ***the very survival of the human race.***

In response to this ***appeal, scientists from all over the*** *world formed* ***the Pugwash Movement. They have been*** ***meeting since 1955, quietly, and solving some of the*** ***most threatening problems of our time. The SALT talks,*** ***Test-Ban Treaty, Non-Proliferation treaty and detente*** ***were all inaugurated by these scientists, working without*** ***publicity, without direct government support.***

But Pugwash itself is threatened. Because of its very *nature it has no base of support—no vested interest to* ***assure its continuance. It needs the commitment of those*** *who* ***understand the significance of the Einstein-*** ***Russell appeal to continue. That is why the scientists of*** ***Pugwash, from East and West alike, are calling on you.***

Your help is urgently needed. With your support, the ***next conference in Mexico will be possible, and the*** ***questions which threaten us daily can be worked on by*** ***scientists far from the pressures of summitry or publicity.*** ***As a*** Bulletin ***reader you are in a unique position to*** ***understand this appeal. So please don't delay. Fill out*** ***the coupon below and become a Friend of Pugwash. Your*** ***contribution is needed for the next conference.***

☐ Please enroll me as a *Friend of Pugwash* and send me summaries of its major meetings. I enclose $100 as my 1978-79 contribution.

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Carl von Ossietzky (1889-1938) received the 1935 Nobel Peace Prize. He was unable to be present at the ceremony nor was he able to prepare the traditional Peace Lecture. He was in "protective custody" in Germany. The award to Ossietzky was interpreted by some as disapproval of the Nazi government, and as a result the Norwegian Parliament resolved that no member of the Nobel committee may, at the same time, serve with the Norwegian government.

1935

A peace worker, a journalist, and a gifted orator, Carl von Ossietzky recognized the gravity of the political situation in Germany in early 1933. He refused to leave the country, saying that a man speaks with a hollow voice from across the border. On February 28, 1933, the morning after the Reichstag fire, Ossietzky was apprehended at home by the secret police, sent to a Berlin prison, then to concentration camps, first at Sonnenburg and later at Esterwegen-Papenburg. In these camps, according to reports from fellow prisoners, he was mistreated, even forced to perform heavy labor although he had already sustained a heart attack.

Ossietzky's candidacy for the Peace Prize was first suggested in 1934. Berthold Jacob, a companion in many a cause, may have been the first to formulate an actual plan to secure the nomination. The idea was taken up by his colleagues in the German League for Human Rights, by Hellmut von Gerlach, a former associate on *Die Weltbühne* who undertook a letterwriting campaign from Paris, by organizations and famous people in many parts of the world. The nomination for 1934 arrived too late; the prize for 1935 was reserved in that year but in 1936 was voted to Ossietzky.

At this point, Ossietzky, ill with tuberculosis, had little time left to live, but the government refused to release him from the concentration camp and demanded that he decline the Nobel Prize, a demand that Ossietzky did not honor. The German Propaganda Ministry declared that Ossietzky was free to go to Norway to accept the prize, but secret police documents indicate that Ossietzky was refused a passport, and, although allowed to enter a civilian hospital, was kept under constant surveillance until his death in May, 1938.

The German press was forbidden to comment on the granting of the prize to Ossietzky, and the German government decreed that in the future no German could accept any Nobel Prize.

Ossietzky's last public appearance was a short court hearing at which his lawyer was sentenced to two years hard labor for embezzling most of Ossietzky's prize money.

• • •

"Carl von Ossietzky, who has been awarded the Peace Prize for 1935, belongs to no political party. He is not a Communist; he is not in any sense a conservative. Indeed, one cannot easily pin on him any of the usual political tags . . . but many people ask, Has Ossietzky really contributed to peace? Has he not become a symbol of the struggle for peace rather than its champion? . . .

The symbol certainly has its value. But Ossietzky is not just a symbol. He is something quite different and something much more. He is a deed; and he is a man.

It is on these grounds that Ossietzky has been awarded the Nobel Peace Prize, and on these grounds alone. His candidacy was examined in the same manner as that of all others, and the decision was reached according to the same principles. If we look back upon all the men and women who have received the Peace Prize over the years, we find that they are of widely divergent personalities and views and that the lives of many of them were marked by passion, grief, and struggle. It is quite obvious that the Nobel Committee in awarding the prize to these different personalities, has neither shared all the opinions which they held nor declared its solidarity with all of their work. The wish of the Nobel Committee has always been to fulfill its task and its obligation, namely, to reward work for peace—that and nothing else. And the Nobel committee has been able to do so because it is totally independent. It is not answerable to anyone, nor do its decisions commit anyone other than itself.

In awarding this year's Nobel Peace Prize to Carl von Ossietzky we are therefore recognizing his valuable contribution to the cause of peace—nothing more, and certainly nothing less."

FREDRIK STANG
Chairman, Nobel Committee
December 10, 1936

Postscript

In June 1978, by a margin of 88 to 1, the Council of Oldenburg University voted to rename it Carl von Ossietzky Universität in Oldenburg. The change has thus far been blocked by state authorities in Lower Saxony, West Germany.

Professor Edvard Pestel, Minister for Science and Culture had indicated that the proposal was not timely in that it would tie future students and faculty to a program that they might not support. He added that there were many other Nazi victims deserving of such an honor, and that in particular those from the political right had also made sacrifices that today were too little recognized. (Broadcast transcript, May 1978)□

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BERNARD T. FELD

The high price of SALT

Nuclear arms control has always been an expensive proposition. What with the assumed need for hasty deployment of bargaining chips before and during negotiations, and the necessity to propitiate Senate hard-liners during the ratification process, we seem always to have emerged rather worse off than we started. Thus, the Partial Test Ban Treaty was paid for by an expensive and uninhibited underground testing program; SALT I and the ABM ban demanded the deployment of multiple warheads (MIRV), and the Trident submarine; and SALT II, in spite of already having called forth strategic cruise missiles and the MX, seems destined to extract still further concessions before it is even signed and put before the Senate. God only knows what the price will be to the right wing for its ratification!

It is, in fact, difficult to escape the strong impression that the final signing of the SALT II agreement, so close for so long, has been stalled for some time by our Administration—and perhaps by the Soviets as well—while awaiting the politically most favorable moment for its launching. Meanwhile, however, in presumably laying the groundwork by propitiating its vocal and hard-line opponents, the longed-for child is being metamorphosed into a monster.

We have long since given up any idea of appreciable arms reduction in this stage of SALT. More serious, what was originally heralded as the beginning of an attempt to place limitations on destabilizing new systems via an interim protocol severely limiting testing has been nullified so as to permit a mobile mode of the MX and cruise missile deployment.

Internally, the hawks are being permitted to call in their chips even before the bidding has started: the only program that has emerged intact from this year's drastic budgetary review is the military. And the Arms Control and Disarmament Agency has been effectively neutralized by placing it under the directorship of an army general—a move which would have been entirely inappropriate even if the new Director had previously shown any zeal for acting as the government's guardian of the arms control approach to national security. In short, the price that has been extracted for a still-nascent SALT II is already excessive even before the ratification fight has begun.

No wonder that a large part of the arms control community is beginning to wonder whether SALT in any form likely to emerge from the current political process is worth the price.

The President and his advisers should perhaps have another look. It may be true that those of us who believe in negotiated arms control and disarmament as the only possible route for averting nuclear war have no place else to go but with the Administration. However, there is a limit to how much we will swallow in the name of political expediency. We are already close to that limit, if not past it.

The Administration must know what we all know, that the American people overwhelmingly believe in nuclear disarmament—not unilateral, not precipitous, but controlled through a meaningful SALT process. We don't expect miracles, but by the same token even the most devoted "peaceniks" will not sit still for a sell-out. Let us hope that it isn't already too late. □

No general need apply

"Whatever the Senate shall decide with regard to the confirmation of Lieutenant General George M. Seignious II (USA, ret.) as Director of the Arms Control and Disarmament Agency, we urge the adoption of a provision of law which would prohibit retired or active duty officers from serving as Director or Deputy Director of ACDA. We observe that ACDA deserves at least as stringent civilian control as does the Defense Department and the latter does have such legislation."*

The above resolution is to be introduced by Senator John C. Culver (D.-Iowa). The Federation of American Scientists circulated the resolution. Among the individual signatories are the former head of the Arms Control and Disarmament Agency, William C. Foster; the historian and former Ambassador to the U.S.S.R., George F. Kennan; the former Ambassador to Japan, John K. Galbraith. Endorsements have been made by New Directions; the Council for a Livable World; the Federation of American Scientists, Americans for Democratic Action, American Friends Service Committee, and the World Federation Association.

** Title 10, Section 34 of U.S. Code: "A person may not be appointed as either Secretary of Defense or Deputy Secretary of Defense within ten years after his retirement from active duty as a commissioned officer of a regular component of an armed force."*

PETER HARNIK

The ethics of energy production and use: debate within the National Council of Churches

You know something is happening
But you don't know what it is,
Do you, Mr. Jones?

That lyric, written by Bob Dylan for a different era, seemed strangely relevant in the Grand Ballroom of New York's Roosevelt Hotel at 9:30 on the morning of November 3, 1978. At that moment, the Governing Board of the National Council of Churches (NCC) was locked in a somewhat surrealistic debate over a lengthy document, two years in the preparation, entitled, "Policy Statement on the Ethical Implications of Energy Production and Use." The amendment, upon which speaker after speaker rose to address the gathering, was to change the title's first two words from "Policy Statement" to "Study Paper."

Dylan's mythical Mr. Jones would have stared in uncomprehending amazement at the spectacle of 250 of the nation's top church leaders clashing over such a trivial point (and even more trivial ones which were to follow shortly); insiders, however, appreciated full well what was occurring: the church was trying to grapple with energy policy—and the Lord wasn't providing any easy answers.

Energy policy? The church? Aren't energy matters a bit technical for the average theologian?

Not at all, says the Reverend Joel K. Thompson, chairman of the NCC's Energy Study Committee, the group that drafted the proposed policy document. Thompson explained in an interview:

"This committee approached the energy question from the perspective that it is much broader than merely the technological issues. It's an issue which has social impact, it's one which has environmental impact, it's one which has moral and ethical dimensions to it. Therefore, the church, which throughout its long history has maintained a perspective on moral and ethical issues, *must* be involved in that fray.

A second role of the church in this particular issue is one of a catalyst. That is, to open up the debate, to get it beyond technology and into its broader dimensions. The church, out of its understanding of society, wishes to have the debate more participatory —to have more rather than fewer people making the decisions that affect us all."

Thompson's ambitious goals were reflected in both the process his committee followed and the document they ultimately produced. With the able assistance of two staff members—Staff Associate for Economic Justice Chris Cowap and Energy Resources Consultant Katherine Seelman—the 12-member committee thoroughly explored the literature, sent out detailed questionnaires, and even visited such sites as coal mines, oil refineries, uranium processing facilities and power plants.

To aid the process, the National Council of Churches established an ad hoc 120-member Energy Study Panel, a diverse and prestigious group composed of workers, businessmen, academics, environmentalists, consumer advocates, minority representatives and ethicists. This panel, which became in effect a resource group for the committee's use, met once as a body, in October 1977, in Stony Point, N.Y., for three days of intensive discussions. The papers arising from that session were used by the committee in drafting the Policy Statement.

The outcome of the two-year process was a 45-page document which had at least two distinctions: it was the first major energy statement ever to look at morality and values rather than hardware and economics; and it was four times longer than any previous policy statement submitted to the NCC Governing Board.

The National Council of Churches of Christ in the United States is a loose federation of 32 Protestant and Orthodox churches, with headquarters in New York and offices throughout the country and overseas. Its governing board meets twice a year to carry out regular business and to vote on policy statements, which can range from such noncontroversial items as censuring political regimes which torture their opponents or calling for peace in the Middle East, to the most difficult dilemmas of our times, like abortion, disarmament, civil disobedience—and energy.

Although NCC endorsement of a policy does not bind any of its member churches to that position, Council support is actively courted by proponents of nearly every issue. For one thing, member churches frequently await an NCC policy decision before formulating their own. Of the NCC member denominations, only the United Methodists have adopted a formal energy policy statement of their own. In explaining why his church, the Church of the Brethren, doesn't yet have an energy position, Thompson said, "We didn't want to duplicate all that effort." But when the National Council of Churches does finally adopt a policy, he added, "it will be the center of the debate, the key starting point for my denomination." Also, NCC policy has a significant impact in Washington where lawmakers frequently invite church representatives to testify on Capitol Hill. Moreover, because the Council acts as a convenient network between member churches, a policy statement on a particular issue can

Peter Harnik, a former editor and coordinator on the staff of *Environmental Action* and a co-ordinator of the National Sun Day celebration in May 1978, is currently a free lance consultant and writer in Washington, D.C.

open the door to a broad flow of information on the subject.

Because of the importance of these decisions, the governing board requires that policy documents pass with a two-thirds majority, and also that they be introduced for a first reading at the semiannual meeting preceeding the one at which the vote is slated. That way, board members and other interested persons can comment on the document, and changes can be made by the committee.

If the Committee on Energy Policy had any thoughts that its policy statement would sail right through, those illusions were quickly dispelled at the governing board meeting in Minneapolis in May 1978 where the document was introduced for its first reading. A chorus of protests rose to the heavens.

The proposed Energy Policy Statement is composed of four sections.

Section one, entitled "Opinions and Perspectives," is a brief introduction which explains that scientists are so divided on most factual matters concerning energy that even straightforward questions about supply, cost, feasibility and impact elicit widely varying answers. Therefore, the committee states:

"Since factual conclusions do not clearly indicate what energy policy to adopt, values now emerge as important guidelines. . . . It is the province of the religious community to address the ethical questions underlying the energy crisis."

Section two is called "Theological Dimensions of the Energy Situation." Using biblical themes, it lays the framework for analyzing energy policy ethically. For instance, it looks at the common Christian theme of "Love Thy Neighbor," and points out that in his day Jesus dramatically expanded the then-current narrow meaning of "neighbor" when he rejected cultural, religious and racial barriers. Today, the document says, we must follow Christ's lead and expand the definition even further to include non-human "neighbors" such as animals, plants and even water and topsoil, as well as yet-unborn "neighbors"—future generations.

Instead of accepting the "subdue-the-earth" mentality of primitive peoples, the policy paper takes the biblical concept of "dominion" and asserts that we must "till and keep" the earth and be responsible "for the wise conservation of the creator's gift of limited energy in order to achieve a more just, sustainable and participatory society. . . . "

Perhaps the section's most interesting—and controversial—discussion is about sin. The document states:

"When faith in the Creator is replaced by faith in human ability to solve all problems by technical means, humanity has fallen into the sin of idolatry. . . . Today, human intelligence and labor and their products as embodied in science and technology are often elevated into . . . counterfeit deities which must be served even at the sacrifice of individual and corporate life and well-being."

It then goes on to assert that the sin of idolatry supports the sin of domination, concluding, "Technological systems tend to become instruments of economic and political domination."

The third section, "Ecological Justice and Human Choice," is the longest and most disputed portion of the Policy Statement. Among others, the section suggests the following ethical guidelines:

- "The needs of those who are below the minimum [economic] standard take precedence over the wants of those above the average."
- Energy policy should assure "the equitable distribution of positive and negative impacts of energy production and use."
- "Other things being equal, those technological projects or developments should be favored that leave maximum room for maneuver in the future. The reversibility of an action should thus be counted as a major benefit; its irreversibility a major cost."
- Wide public participation should be assured, including particularly "the views of those who will be affected by a particular action."
- In seeking to reach an ecologically just society, the means used—the energy policies chosen, even those chosen as interim strategies—must also be ecologically just.
- In order to minimize the damaging effects of the "boomtown syndrome," urban areas "should move toward greater energy sufficiency and conservation, and corporations toward increased payment of local revenues and social audits of their activities."
- Energy technologies should be assessed to see how close they come to the goal of being "resilient, flexible, pluralistic, noncentralizing, benign, inequity-reducing, non-violent, resource-saving, pleasing to the senses, and simple."
- A social impact assessment should also be conducted which addresses "community development, employment, industry development, land use, health and community services."

In a few cases, the section takes even stronger positions:

- It calls for stringent conservation by the affluent and a strong commitment to the development of renewable energy resources.
- It states that large-scale facilities such as nuclear plants "are frequently inappropriate" for the economies of Third World countries.
- It questions the assumption that high energy consumption and a high standard of living go hand in hand.
- It calls for the consideration of energy stamps, utility rate reform and oil rationing.
- It states, "Plutonium is not a fuel appropriate to the dimensions of human nature."

The fourth section, "A Challenge to the Churches," is a brief but re-

A debate on morality is a completely open and democratic one; nothing can be shrouded in the mysterious language of 'experts' that the energy industry uses so effectively to intimidate its opponents.

markably forceful conclusion which calls upon Christians everywhere to become active in finding solutions to the energy crisis.

One of the earliest critics of the then-emerging Energy Policy Statement was Father Olof Scott, a 36-year-old Charleston, W. Va., minister with the Antiochan Orthodox Christian Church, who came as an observer to the "Energy Ethics Consultation" at Stony Point. Scott, who had been a nuclear engineer for ten years with General Electric, Public Service Company of New Hampshire and Westinghouse before joining the ministry, became troubled at what he perceived as the anti-nuclear tenor of the assembled experts.

"At Stony Point," Scott explained later, "I could only count approximately five out of the 100 or so attendees who really accepted nuclear power as an energy source that could provide adequate and reliable power in the coming years." When informed of Scott's charge, NCC staffer Chris Cowap responded that 14 of the 120 Energy Study Panel members had nuclear expertise and that, in fact, "the nuclear community may have even been over-represented." She conceded that not all the experts were pro-nuclear, but added, "I find it difficult to accept that if you're a nuclear engineer but not pro-nuclear, all of a sudden you're not an expert but some kind of proponent for a weird cause."

Scott sprang into action, writing a lengthy, rambling rebuttal of the Policy Statement, which he called "The Moral (?) Atom." In it he argued that plutonium cannot be fundamentally evil because it was created by God, and everything created by God is good. His primary contention was that every technology is needed to solve the energy situation, and that if the NCC rejected nuclear power it was obligated to look at the impact of that action on our lifestyle and on the Third World. Scott's rebuttal largely avoided discussing the ethical criteria painstakingly addressed by the NCC committee, but it did serve to define the battle along pro-nuclear/anti-nuclear lines.

This was not to be the first nuclear controversy fought within the confines of the NCC governing board. Ironically, the entire energy policy project had grown out of a two-year nuclear battle beginning in 1974. At that time the NCC had asked Margaret Mead and Rene Dubos to chair a committee which would draft a policy on plutonium. When they returned with a recommendation calling for a ban on the substance, reaction from the atomic establishment was so fierce that the policy was softened into a "resolution," and the new energy committee—Thompson's —was created to study the full energy picture rather than only one isolated portion of it.

Katherine Seelman, NCC consultant, said in an interview:

"We'd been getting feedback on the policy drafts all along. I've got a stack of mail that's about four feet tall next to my desk. But when the electric utilities saw that line about plutonium, they really turned on the pressure. They started taking board members out to lunch, calling ministers, arranging special presentations through the local churches. One utility executive told me, 'Katherine, anyone who takes the position on plutonium that the Council takes is going to get the kind of response and lobbying that you've received.' "

Ironically, even if committee members had been persuaded by the pressure to change their minds, they did not feel they had any real flexibility on the issue of plutonium since the full NCC governing board had already passed the anti-plutonium resolution in 1976. "As long as that resolution stands," Cowap said, "we're bound by it."

Nevertheless, everyone was aware of the depth of feeling on both sides as the vote neared. Thompson stuck to his pledge to keep the process open by designing a rather elaborate pre-vote procedure at the Hotel Roosevelt. First, two brief statements about the policy document, one pro and one con, were delivered to the full board. Then the board members separated into five working groups to discuss the paper and to formulate questions they wanted answered. These questions were put to a panel of eight energy experts—again, four pro-statement and four con.

The vote on the energy policy was the first on the agenda for Friday morning—giving board members 12 hours for last-minute politicking.

The governing board of the National Council can, in a general way, be compared to the U.S. House of Representatives. Each member church is alloted representatives based on a formula that takes into account size of the denomination and size of its financial contribution to the NCC. (The largest delegations are those of the United Methodists, the Episcopalians, the Lutheran Church in America, the American Baptist Churches, and the Presbyterian Church in the United States.)

Proportionally, the board has more blacks and women than Congress, but appears to be of about the same median age and just about the same class—middle to upper-middle. Unlike Congress, board members are nominated rather than elected, but they do represent every section of the country. Like Congress, the delegations appear to have some common bonds internally but by no means vote in blocs.

The most interesting parallel with Congress is the fact that no issue is beyond the church's realm of interest and, on energy at least, the church has no vested position. In other words, the groups in our society which are advocating one energy strategy or another—the oil industry, for instance, or environmentalists—have already formulated their policies; it is now the middle-of-the-road, multi-issue organizations such as the NCC which are struggling with opposing factions. The struggle within

Americans, even those high in the religious community, are so accustomed to making decisions based on economics first and technology second that they have trouble keeping ethics on center stage.

the Council is a miniature version of the struggle within Congress, which is, of course, a reflection of the struggle throughout the society.

Several other factors added to the confusion that many were feeling on the night before the vote.

One was the fact that another important religious body, the World Council of Churches (WCC), headquartered in Geneva, Switzerland, was also grappling with the energy problem and was tilting sharply toward nuclear power. Although the WCC energy committee structure is not comparable to that of the National Council of Churches'—the World Council of Churches is not focusing on ethics; its nuclear statement does not constitute policy; and another WCC committee is aggressively promoting conservation and appropriate technology—there were constant rhetorical references to the seeming contradiction. One side kept asking, "How can we so blatantly cross our international brethren?" while the other responded, "We must provide the leadership to turn them around!"

The other troubling event was the dismissal the day before of the Reverend Dr. Lucius Walker, Jr., head of the NCC's Division of Church and Society, which housed the Committee on Energy Policy. The official reason for Walker's dismissal was that he had overspent his division's budget by $228,000 over two years—$25,000 of which was attributable to extra energy statement expenses—even though he had been warned to tighten up on spending. There was widespread feeling, however, that Council conservatives had pressed for Walker's removal because of his strong stance in controversial areas, such as energy. If the charge were true, it didn't bode well for the committee's position on the vote the next day.

In most crucial political showdowns, the key decision is made before the vote. For the NCC's energy policy, the decision came at about 8:00 on Friday morning. Chris Cowap found out about it at 9:28:

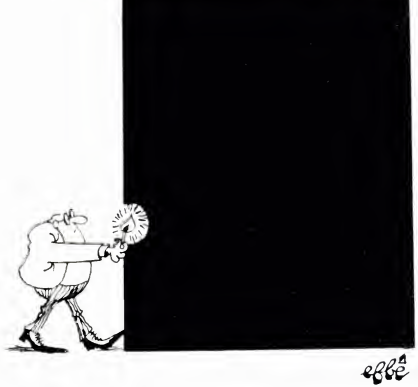
"About two minutes before we were to go on," she said, "we got word that the heads of many of the communions had gotten together for breakfast and agreed to postpone the decision. Neither side felt it had the votes, and neither side wanted to lose. I don't agree with their analysis, but it was too late to do much about it."

Nevertheless, there were still several important procedural decisions to be made, and there was spirited jockeying between the factions to determine which side was stronger and what ultimately would happen to the energy policy statement.

Opening the debate was the Reverend Dr. James Crumley, once a pastor at Oak Ridge, Tenn., now president of the Lutheran Church in America and a strong opponent of the policy paper. He proposed a package of amendments which would have changed the policy statement into a "study document," urged its broad dissemination to churches across the country, and postponed a vote on energy policy until 1981 at the earliest. His package would also have taken the energy committee out of the Division of Church and Society and placed it under a less progressive interdivisional body.

Proponents, represented by Dr. Avery Post, president of the United Church of Christ, countered with strengthening amendments but stuck to the "deal" by agreeing to the change from a policy statement to a study document. Post's amendments inserted language which praised the study document as a good one and directed that a "concise version" be presented by the same committee for consideration in May 1979.

After considerable symbolic debate, including a vote on whether the Board should "issue" or "commend" the study document to the churches, the National Council of Churches issued the paper and agreed that it could come up for a vote at the next governing board—if another committee waived the first reading



requirement at that time. And with that, the debate ended.

What are some of the lessons to be drawn from the NCC debate? Here are a few of my thoughts:

• The two opposing sides are relatively evenly matched. Those who advocate soft energy technologies have come a long way from the "fringe," while advocates of conventional strategies have been seriously undermined in the past few years. Based on the NCC outcome—and, more blatantly, on the outcome in Congress this year—the latter group is still stronger, but not much.

• The energy industry doesn't want the ethics of energy debated. For one thing, a debate on morality is a completely open and democratic one; nothing can be shrouded in the mysterious language of "experts" that the industry uses so effectively to intimidate its opponents. Moreover, since the entire energy pyramid is based on economics rather than morality, an ethical investigation is bound to reveal anomalies that only make sense on Wall Street.

• Conversely, energy industry critics need the debate shifted to the ethics arena. Since the industry is almost invulnerable to attack on the economics front, critics are constantly seeking to change the forum in order to go on the offensive. Interestingly, some of the most outspoken energy companies, such as Mobil and Arco, are gradually picking up phrases and arguments from the ethics side of the debate, at least in their advertising.

• People find it difficult to focus on the ethics of energy production and use. Americans, even those high in the religious community, are so accustomed to making decisions based on economics first and technology second that they have trouble keeping ethics on center stage. Of course, the actual ethics debate—the merits of the policy statement itself—never took place at the November meeting, but it was clear to observers that the governing board had largely become divided over economic, technological and lifestyle prejudices rather than ethical questions. (I have been assured that discussions in local churches did concentrate more on ethics; one hopes that this will become more common as we get used to a "new" approach.)

• The church today is not anxious to move any faster than society as a whole. The current feeling in the National Council of Churches is that it must stay in the mainstream of popular opinion, keeping a comfortable distance from both innovators and stragglers. The energy decision was a reaffirmation of moderation, first by deferring a vote on what is clearly a leadership document, and then by rejecting a die-hard proposal to delay any policy statement until the 1980s.

•There is a huge information gap between energy experts and the general public. While the experts on both sides of the issue develop more sophisticated and arcane arguments every week, there seems to be resistance by the average person to dealing with energy at all. Although the NCC decision appeared to be a victory for those who demanded more time for study and reflection on the complex questions, these are precisely the people who have procrastinated for the past two years, even though the issues were front-page news every day. Conversely, the experts have focused on each other so much that they have often intimidated—or, more likely, bored—nonspecialized audiences to the point of driving them away.

• Running away from the energy debate won't make it go away. It's obvious that a great deal of behind-the-scenes maneuvering will be going on at the National Council of Churches between now and May. But I could not get a single insider to hazard a guess about what the outcome of the battle would be—or even when it would be fought.□

For a copy of *Energy and Ethics: The Social Dimensions*, published by the National Council of Churches Energy Project in January 1979, write the NCC, 475 Riverside Drive, Room 572, New York, N.Y. 10027.

THE bulletin OF THE ATOMIC SCIENTISTS

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THE bulletin OF THE ATOMIC SCIENTISTS

The lives of the people of the Marshall Islands have been irreversibly changed by the U.S. nuclear bomb tests.

GIFF JOHNSON

Micronesia: America's 'strategic' trust

On August 6, 1945, the B-29 Enola Gay dropped the first of two atomic bombs that would kill over 200,000 people in Hiroshima and Nagasaki. Within months the United States began searching for sites far from American population centers for further development and testing of nuclear weapons. The Defense Department looked to Micronesia in the western Pacific, whose 2,000 remote islands have only one-half the land area of the state of Rhode Island.

Easternmost in Micronesia lie the Marshall Islands, about 2,200 miles southwest of Hawaii. Up to the 1940s the Marshall islanders, like most other Micronesians, were self-sufficient, living off the ocean and land. Though covering a great expanse of ocean, the Marshalls' 28 multi-islet atolls and five single islands comprise only about 70 square miles. The atolls are rings of 15 to as many as 97 islets connected by a coral reef that encircles a clear blue lagoon. Out of necessity, the Marshallese are traditionally expert fishermen, deriving most of their protein from the rich lagoons, while the land provides coconuts, breadfruit, pandanus and taro.

The most isolated and least westernized of the Marshallese lived on the northern atolls of Bikini and Enewetak. Having little contact with foreigners (not even with the Japanese during their 25-year occupation), they relied on the outside world for almost nothing.

Ironically, this very isolation thrust the Bikini and Enewetak people into the nuclear age.

In January 1946, Navy officials in Washington, D.C., announced that Bikini Atoll fitted all requirements for *Operation Crossroads,* designed to test the destructive power of nuclear weapons on naval vessels. When the U.S. military governor of the Marshalls went to Bikini in February, he told the people that American scientists were experimenting with nuclear weapons "for the good of mankind and to end all world wars." He promised that their atoll would be returned after the tests were finished, and asked that they consent to be moved to another island. With more than 42,000 military, scientific and technical personnel, 250 naval ships and more than 150 observation aircraft poised to enter Bikini Atoll for *Operation Crossroads,* the 166 Bikinians had little choice but to leave their island.

Less than two years later, in December 1947, the Navy decided to use another atoll, Enewetak, for a second series of atomic tests. The Enewetakese, like the Bikinians, were relocated by the United States quickly and with little planning to small, uninhabited atolls.

Even while the United States was removing the Marshallese from their islands, in July 1947 it was signing the United Nations Trusteeship Agreement for the U.S. Trust Territory of the Pacific Islands (Micronesia). This agreement stated:

"In discharging its obligations, the administering authority [U.S.] shall: promote the economic advancement and self-sufficiency of the inhabitants, and to this end shall . . . encourage the development of fisheries, agriculture and industries; and protect the inhabitants against the loss of their land and resources."

In addition, this agreement bound the United States to "promote the social advancement of the inhabitants, and to this end . . . protect the rights and fundamental freedoms of all elements of the population without discrimination; and protect the health of the inhabitants. . . ."

After the relocation of the Marshallese, however, what happened during the next 12 years was that about 70 atomic and hydrogen bomb blasts devastated the islands and irreversibly changed the lives of the people.

The Bikinians first moved about 100 miles east to Rongerik, an uninhabited atoll consisting of barely one-half square mile of land. Within two months, they expressed anxiety over the atoll's meager resources and made the first of many requests to return home. Within a year, the people faced starvation; a visiting American medical officer reported that the Bikinians were "visibly suffering from malnutrition." In 1948 the Bikinians were evacuated to a temporary tent city at the Navy base on Kwajalein.

Kili Island in the southern Marshalls was selected for their next home. Kili, a single island, has no lagoon or protected anchorage; heavy surf from November until late spring halts fishing and isolates the island. On the other hand, Kili had once supported a Japanese copra plantation, and U.S. authorities hoped that, while the Bikinians were not a farming people, the island's agricultural possibilities would overcome its drawbacks. Thus, the Bikinians were forced to adapt to a completely alien environment.

In early December 1947, Washington officials announced without preliminaries, that Enewetak was to be used for the next series of bomb tests. In less than three weeks, the people of Enewetak were relocated to Ujelang, the westernmost atoll in the Marshalls. Like Rongerik and Kili it was also uninhabited, and for good reason. Ujelang has only a quarter of the land area of Enewetak and its 25-square-mile lagoon is less

The last church service on Bikini, March 1946.

than 1/15 the size of Enewetak's 390-square-mile fish-filled lagoon.

Because the islands could not support the growing Marshallese populations, critical shortages of food and water occurred. More than once air drops of emergency food rations were needed to prevent starvation.

In 1952, the first hydrogen device was tested at Enewetak. The blast, estimated at 10.4 metagons, completely vaporized one island in the atoll and left a crater one mile in diameter and 170 feet deep in the coral reef.

On March 1, 1954, the United States detonated *Bravo*, the first test of a deliverable hydrogen bomb, at Bikini Atoll and severely contaminated fishermen aboard the *Lucky Dragon*, a Japanese fishing vessel that had strayed into nearby waters. More than 200 Marshallese on the neighboring atolls of Rongelap and Utirik, and some 28 Americans monitoring the explosion were also contaminated.

The U.S. Atomic Energy Commission called *Bravo* a "routine atomic test." But it was far from routine.

Despite an incomplete and alarming weather report indicating that winds from sea level to 55,000 feet were blowing in an easterly direction toward Rongelap and Utirik, the test proceeded.

The *Lucky Dragon*, illegally fishing near Bikini, was the first thing hit by the radioactive fallout. Returning to Japan quickly, unaware that they had been exposed to nuclear fallout, the 22 fishermen began to feel the effects of acute radiation exposure: itching of the skin, nausea and vomiting. Within two years the Japanese government received $2 million in compensation for the fishermen's suffering.

In the AEC's Nevada Nuclear Proving Grounds in the United States, prior to an atomic test series, a public information program, including films and discussions on the forthcoming tests, was implemented. No such programs had been conducted in the Marshalls, although the United States did inform the chief of Rongelap that a hydrogen test would soon occur. What the chief was told about the test, and what his reactions were is not clear; that he knew nothing of the radiation disaster soon to befall his people is certain. Indeed, the Marshallese on Rongelap and Utirik were not even warned of precautionary measures they might take in the event of radiation exposure.

Instead, the Marshallese were astonished observers of the snowlike fallout that covered them and their islands. On Rongelap the white ash soon formed a layer one-and-one-half inches thick on the ground and fell into the drinking water tanks. Children played in the radioactive powder and an old man with vision problems rubbed the ash into his eyes to see if this might somehow cure his ailment.

The 28 RadSafe (radiation monitoring) personnel on Rongerik Atoll intensified their observations following news of the nuclear cloud's erratic behavior. About seven hours after *Bravo*'s detonation, radiation levels on Rongerik exceeded their monitoring instrument's maximum scale of 100 millirads per hour. Instructed to take strict radiation precautions, the RadSafe team put on extra clothing and remained inside the tightly shut building until their evacuation 34 hours after the test. Medical reports on these men are still unpublished.

Utirik's 157 men, women and children were the last to experience *Bravo*'s fallout 22 hours after the explosion.

The Rongelap people were exposed to 175 rems of gamma radiation, considered a high dose of radiation. (A lethal dose is estimated at 300 to 500 rems in the absence of intensive medical care.) Nevertheless, they were not evacuated from the island for more than 24 hours *after* the Americans left Rongerik, which is only about 25 miles away. The Utirik population was not removed by the United States until more than three days after the *Bravo* test.

After their evacuation to the Navy base at Kwajalein, many of the exposed Marshallese began to experience the effects of severe radiation poisoning: itching and burning of the skin, eyes and mouth; nausea; vomiting and diarrhea. Later in the month, in the second stage of acute radiation exposure, many of the people began to wholly or partially lose their hair, and skin burns began appearing on the necks, shoulders, arms and feet of those most heavily exposed.

The Utirik people were told by the Atomic Energy Commission that "their island was only slightly contaminated and considered safe for habitation," and they were moved back in May 1954.

Three years later the Rongelapese were permitted to return home—after a July 1957 radiological survey stated that "in spite of slight lingering radioactivity" Rongelap Atoll was safe for rehabitation. With this dubious recommendation, the Rongelapese returned. Brookhaven National Laboratory (on contract to the AEC) reported that:

"Even though . . . the radioactive contamination of Rongelap Island is considered perfectly safe for human

Giff Johnson, a free lance writer who has traveled extensively throughout the Pacific, edits the *Micronesia Bulletin* published in Honolulu, Hawaii 96826.

habitation, the levels of activity are higher than those found in other inhabited locations in the world. The habitation of these people on the island will afford most valuable ecological radiation data on human beings."

Even at the outset of its medical treatment program, the AEC seemed willing to experiment with the exposed Marshallese islanders.

Up to 1958 the incidence of stillbirths and miscarriages in the exposed Rongelap women was more than twice the rate of unexposed Marshallese women.

In 1961, a Brookhaven National Laboratory report (prepared for the AEC) showed that after the exposed Rongelap people returned to their island in 1957 their body burden of radioactivity rapidly increased. In 1961 their body levels of radioactive cesium had risen 60-fold, zinc rose 8-fold and strontium-90 rose 6-fold.

In 1964, the first thyroid tumors and cancers appeared. Since that time, more than 90 percent of the Rongelap children who were under 12 years old in 1954 have developed thyroid tumors. Forty percent of all the exposed Marshallese have developed thyroid problems, as compared to an average of 3 or 4 percent among Americans.

Some people who returned to Rongelap in 1957 had been away from the island when the bomb exploded and therefore had not been exposed to radiation.

Brookhaven's 1960 medical survey showed little difference in radioactivity levels among exposed and unexposed people living on Rongelap. However, as late as 1969, the body radioactivity levels of previously unexposed Rongelap people was *10 times* that of Marshallese living on a noncontaminated island.

In 1971, Marshall Islands leaders invited a Japanese medical team to perform an independent survey of the Rongelap and Utirik people. Barred by the United States from actually going to Rongelap and Utirik, the team examined exposed people in the district center of Majoro. The Japanese report stated:

"The people of Rongelap who were not exposed to fallout, received a considerable amount of radioactive nuclides from the environment. Consequently, the 'unexposed' group actually became an 'exposed' group . . . it was a great mistake to permit the people of Rongelap to return to their island in July 1957 without sufficient work having been done to remove radioactive pollution from the island."

In 1972, Lekoj Anjain, who had been only a year old at the time of his exposure in 1954, died of myelogenous leukemia at the National Cancer Institute in Bethesda, Maryland.

The Atomic Energy Commission has consistently obscured information about the irradiation of the people and their high incidence of thyroid disease and cancer. In 1975 Nelson Anjain, Rongelap's magistrate, wrote to Dr. Robert Conard of Brookhaven:

"For me and the people on Rongelap, it is life which matters most. For you it is facts and figures. We want our life and our health. In all the years you've come to our island you've never once treated us as people. You've never sat down among us and really helped us honestly with our problems. You have told the people that the 'worst is over,' then Lekoj Anjain died. I am very worried that we will suffer again and again."

The Utirik people were suffering as well. Because their exposure was considered "small," tests on genetic and second generation effects were not conducted on them. The Atomic Energy Commission had always told the Utirik people that the 14 rads of radiation they had experienced was too insignificant to be harmful. Nevertheless, in 23 years the Atomic Energy Commission treated 11 reported cases of thyroid tumors, 3 of them malignant, out of a population of only 157.

But suddenly in 1977 the cancer and thyroid disease rate among the Utirikese rose so sharply that it equalled that of the much more heavily exposed Rongelap population. This unexpected increase has forced government scientists to revise theories on which radiation dose rate will lead to adverse human effects.

"Thyroid nodules have been increasing in the Utirik people and this was quite unpredicted and we had some of the best experts in the United States," said Dr. Conard, who has headed the Atomic Energy Commission and now ERDA (Energy Research and Development Administration) medical program in the Marshalls since 1954.

"The theory was put forth that Utirik received low radiation so a detailed follow-up was not necessary," said Dr. Konrad Kotrady, a former

Up to the 1940s the Marshall islanders, like most other Micronesians, were self-sufficient living off the ocean and land.

Brookhaven resident physician in the Marshalls. "Now the facts of the thyroid cancer at Utirik have strongly shown that the theory was wrong," Kotrady wrote in a stinging critique of the ERDA medical program. "The people ask if this thyroid problem has suddenly occurred is it not possible that the experts have been wrong for so many years and that more problems will occur in the future?"

Despite the inability of the AEC's "experts" to predict the thyroid cancers among the Utirik population, they have adamantly barred outside medical teams from the islands. Not until the Rongelapese and others refused to undergo the 1972 AEC medical examinations unless independent doctors participated were two doctors added to the AEC team for that examination.

Every year since 1954, the AEC and later ERDA medical teams have examined the Marshallese people, and every year they reassure them of their good health. When the people eventually began asking, "If nothing is wrong with us, why do you keep coming back every year to examine us?" ERDA replied that it was a precautionary measure.

Although the AEC/ERDA has treated the Marshallese for 24 years, a study by a special committee of the Congress of Micronesia stated, "Time and again the committee found that the people did not understand *anything* about their exposure, the possible effects on themselves and to their children and on their environment."

Protesting what they considered inadequate medical care and to underline the monumental cultural clash between the U.S. medical personnel and the islanders, the Utirikese refused a quarterly ERDA medical checkup on December 1976, and the ERDA physician was recalled. "The people of Utirik are very distressed and angry as a result of the radiation," the chiefs of the atoll wrote the Energy Research and

(left) Nuclear bomb crater, Enewetak Atoll. (below) Leaving Bikini, carrying pandanus leaves to build new houses on Rongerik. Suffering from malnutrition, the Bikinians are evacuated to a tent city on Kwajalein.

On Rongelap, the white ash formed a layer 1½ inches thick on the ground; it fell into the drinking water tanks and the children played in the radioactive powder.

Development Association in 1977. "The people feel that the ERDA program is in need of vast changes."

While the Utirik and Rongelap populations were experiencing the effects of direct fallout exposure, the peoples of Bikini and Enewetak were attempting to survive in their U.S.-imposed exile on tiny, inhospitable islands.

Because living conditions on both Kili and Ujelang deteriorated further during the late 1950s and early 1960s, the United States instituted small trust funds in an effort to alleviate some of the problems. For the Enewetak people the trust fund was $150,000 and for the Bikinians it was $300,000, both yielding semi-annual interest payments (approximately $15 per capita for the Bikinians).

By the mid-1960s the people were demanding a return to their home islands. Because the Bikinians and Enewetakese began to receive extensive international publicity for their plight, the pressure increased on the United States to return them to Bikini and Enewetak. In addition, the Atomic Energy Commission, which had been increasingly criticized for advocating that there were "permissible levels" of radiation exposure, was eager to demonstrate that low levels of radiation were not harmful to people.

In 1968, ten years after the Marshalls' nuclear test program had ended, President Lyndon Johnson promised the 540 Bikini people a permanent return to their home; the radiation had dropped below the danger level, according to the Atomic Energy Commission. In 1969, an AEC radiological survey stated, "There's virtually no radiation left and we can find no discernible effect on plant or animal life (on Bikini)."

In the early 1970s the Bikinians began slowly returning to their atoll to help in the massive rehabilitation program, which included the replanting of more than 50,000 coconut trees and many other local crops, as well as construction of a new village.

About 100 Bikinians were on the atoll when the Lawrence Livermore Laboratory conducted a radiation assessment in June 1975. The study, "Dose Assessment at Bikini Atoll," not released until mid-1977, stated clearly: "All living patterns involving Bikini Island exceed federal (radiation) guidelines for 30-year population doses." A preliminary report issued by Energy Research and Development Association in August 1975 pointed to the need to restrict completely the use of pandanus, breadfruit and coconut crabs (a dietary mainstay in the Marshalls).

Despite these and other warnings, Energy Research and Development Association's Dr. Conard stated a short time earlier:

"Our medical team has evaluated the radiation exposure in the people who have been working on Bikini the past two years. There is some low level radiation remaining on the island of Bikini and measures have been taken to reduce these levels. . . . The internal absorption of radioactive materials will be . . . only slight from terrestrial food plant sources. Therefore, we do not expect to see any ill effects in the Bikini people or in their offspring from the small amounts of radiation to which they will be exposed."

Caught in the middle of these conflicting statements, in late 1975 the Bikinians filed a federal law suit against the U.S. government demanding a complete scientific survey of Bikini to determine if the island was indeed safe for habitation.

In late 1977, ERDA monitoring of the Bikinians who had returned ear-

Because living conditions deteriorated further the United States instituted small trust funds. For the Bikinians, the trust fund yielded semi-annual interest payments of approximately $15 per person.

lier showed a marked increase in the amount of radioactive nuclides in the people's bodies. These tests show that the Bikinians were ingesting higher than acceptable concentrations of cancer-causing radiation from the water and from food grown in the island's contaminated soil. The U.S. government then began importing all food (except local fish, which was declared safe) and drink to Bikini. This food program has compounded the Bikini dilemma; while the Bikinians have been told that the island is radioactive and potentially dangerous, the prospect of free food and housing and a chance to move from Kili—called the "prison" by residents—has encouraged people to return.

In early 1978, the Energy Research and Development Association considered moving the people to another island in Bikini Atoll—Eneu—and was growing fruits and vegetables in an experimental garden to test radioactivity levels there. Results from these experiments, however, weren't expected for about a year.

According to a careful report in the Los Angeles Times, by February 1978 it was official government policy: Bikini was unfit for people to live on. Nevertheless, in April, Trust Territory officials, testifying at a congressional hearing on funding for re-establishing the Bikinians on Eneu Island, insisted that the people could remain on Bikini *without harm* until the experiments on Eneu were completed in January 1979—provided that they didn't eat any coconuts, and that the coming medical tests showed, as was expected, no large increases in internal radiation levels.

In the April 1978 medical examinations, however, the Bikinians' internal radiation levels ranged up to 0.980, or nearly *twice* the U.S. maximum safety standard of 0.5 rems. At the same time, the preliminary results from the experimental garden at Eneu Island showed that radioactivity levels were 5 to 6 times higher than expected.

Throughout the rehabilitation of Bikini, the Energy Research and Development Association and the Department of Energy had conducted countless radiological surveys of the island—many of which suggest the Bikinians were unwitting subjects for scientific radiation tests. A recent study for the Department of Energy concluded that "Bikini Atoll may be the only global source of data on humans where intake via ingestion is thought to contribute the major fraction of plutonium body burden."

A 1976 Lawrence Livermore Laboratory scientist stated that Bikini "is possibly the best available source of data for evaluating the transfer of plutonium across the gut wall after being incorporated into biological systems."

Government scientists vehemently deny they have used the Marshallese for experimentation. A DOE official explained, "It was done by technical types anxious to know about the transfer of radioactive elements."

Interior Department officials announced in May 1978 that the atoll would be evacuated within 90 days, and the people returned to Kili Island. In late August, Interior representatives went to Bikini to supervise the evacuation, in many ways reminiscent of the 1946 removal. "There are some things we didn't feel good about," said Taro Lokebal, who serves as liaison between the Bikini Council and the United States. "The (U.S.) High Commissioner made the people rush. . . . Some things were left behind—pigs, chickens, lumber. We had to have our ceremony on the ship. It was supposed to be on the shore but we had no time."

Though the Bikinians, like the Enewetakese, suffered the devastating physical and psychological effects of relocation and, at times, even near starvation, they had never suffered radiation exposure until they returned to their radioactive island after 25 years. Now the Bikinians are an exposed population, too. And who knows what the future holds for the Enewetak people—many of whom have now returned to their home atoll to work with thousands of U.S. army soldiers in the massive nuclear debris cleanup.

Until the scientific community and independent organizations begin critically to monitor U.S. government agencies' treatment of the Marshallese, their situation is not apt to change.

From the nuclear bomb tests at Bikini and Enewetak to the medical treatment of the irradiated islanders, the 30 years of American trusteeship has brought the Marshallese anything but the conditions promised in the U.N. trust agreement.□

Conard, Robert A., M.D., et al., *A Twenty Year Review of Medical Findings in a Marshallese Population Accidentally Exposed to Radioactive Fallout*. Brookhaven National Laboratory. Washington, D.C.: Department of Commerce, 1975; available from National Technical Information Service.

Congress of Micronesia Special Joint Committee Concerning Rongelap and Utirik: 1973 Report. Kolonia, Ponape 96941: The Congress.

Detroit Free Press, Sept. 2, 1978.

Gensuikin (Japan) Medical Survey Team. *Report on the Investigation of Damage Done by the Bikini Hydrogen Bomb Test to the People of the Marshall Islands*. rev. ed.; Tokyo, Japan: Gensuikin, 4th fl., Akimoto Bldg., 2-19 Tsukasa-Che, Kanda, Chiyoda-ku, Tokyo, 1973.

Honolulu Advertiser, Oct. 10, 1975; June 16, 20, 21, and 22, 1977; March 19, 1978; July 30, 1978.

International Herald Tribune, April 19, 1978.

Kiste, Robert C. *The Bikinians: A Study in Forced Migration*. Menlo Park, Ca.: Cummings Publishing Co., 1974.

Lawrence Livermore Laboratory. *Dose Assessment at Bikini Atoll*. UCRL-51879 Pt.5. Washington, D.C.: Department of Commerce, June, 8, 1977; available from National Technical Information Service.

Los Angeles Times, June 11, 1977.

McHenry, Donald F. *Micronesia: Trust Betrayed*. Washington, D.C.: Carnegie Endowment for International Peace, 1975.

Micronesian Independent, Sept. 12, 1975.

New York Times, March 23, 1978.

Washington Post, March 23 and 27, 1978; April 3, 1978.

An analysis of misconceptions about thorium-based fuel cycles as a technical fix to the nuclear proliferation problem.

AMORY B. LOVINS

Thorium cycles and proliferation

This paper analyzes several prevalent misconceptions about nuclear fuel cycles that breed fissile uranium-233 from thorium. Its main conclusions are:

- Uranium-233, despite the gamma radioactivity of associated isotopes, is a rather attractive material for making fission bombs, and is a credible material for subnational as well as national groups to use for this purpose.
- "Pure" thorium cycles, which in effect merely substitute uranium-233 for plutonium, would take many decades and much uranium to establish, and offer no significant safeguards advantage over plutonium cycles.
- "Denatured" thorium-uranium cycles, which dilute the uranium-233 with inert uranium-238 to a level not directly usable in bombs, are not an effective safeguard even against subnational bomb-making. This is because three factors—higher initial fissile content, larger mass difference between isotopes, and smaller amount of material needed for a bomb—make such "denatured" uranium-233/238 fuel one or two hundred times easier to enrich to bomb-usable levels than natural uranium. Such enrichment can be done at a modest scale with readily available centrifuges.
- Several other features of mixed thorium-uranium cycles are rather unattractive from a safeguards point of view.
- Thus thorium cycles of any kind are not a technical fix for proliferation (national or subnational) and, though probably more safeguardable than plutonium cycles, are less so than once-through uranium cycles that entail no reprocessing.
- While thorium cycles have some potential technical advantages, including flexibility, they cannot provide major savings in nuclear fuel resources compared to simpler ways of saving neutrons and uranium.
- Thus while advocates of nuclear power may find thorium cycles worth exploring, such cycles do not differ fundamentally from uranium cycles in any of the respects—including safeguards and fuel resources—that are relevant to the broader nuclear debate, and should not be euphorically embraced as if they did.—A.B.L.

If nuclear fission is to be used as an energy source, whether it should use fuel cycles that require plutonium to be extracted and re-used turns on two independent questions [1]. The first is whether plutonium is bearable and the second is whether a lot of uranium is available (geologically and politically) at relatively low prices. Few if any analysts answer yes to both questions; and for any who do, policy choices are unconstrained. Those who believe plutonium is bearable and uranium scarce build fast breeder reactors. Those who believe plutonium is nasty and uranium plentiful write Ford-MITRE reports. Those who believe plutonium is nasty and uranium may be scarce call attention to fuel-efficient, non-plutonium fuel cycles. It is this last, perhaps most interesting, group that has recently recalled attention to thorium-based fuel cycles which appear to many nuclear advocates to merit study on several grounds, potentially greater resistance to the proliferation of nuclear weapons being high among them.

It is this cluster of proposals, and some prevalent misinterpretations of them (especially common in Britain and Canada), that this article briefly discusses. The arguments of critics of the plutonium economy are taken as read. Nothing in this article should be construed to imply that:

- the proliferation risks of plutonium fuel cycles can be made tolerable, or
- any commitment (even an exploratory one) to a plutonium economy need be made for many decades, perhaps even a century or two,
- any improvement in existing safeguards (such as those sought by the Carter administration) is not worth making only because it does not solve the whole problem, or
- any form of nuclear power is necessary or desirable.

All these fallacies are addressed elsewhere [2]. While some of my arguments have been previously advanced by advocates of plutonium fuel cycles, presumably seeking to suggest that their option is acceptable because the thorium alternative to it is nearly as bad, I shall suggest that *neither* is acceptable. Thus any out-of-context quotation of this paper in support of plutonium cycles would be perverse and misleading.

Since proposals were widely published in 1976-1977, notably by Taylor and Feiveson [3], for a "denatured" [4] thorium cycle which might be less proliferative (especially to subnational groups) than a plutonium-uranium fuel cycle [5], some people [6] have jumped to the conclusion that thorium cycles in general and denatured thorium cycles in particular offer a technical fix to the proliferation problem. This is incorrect. It is also certainly not what such authors as Taylor, Feiveson, Cochran, and von Hippel had in mind: they proposed denatured thorium only as proof of the existence of fuel cycles which might, on closer study, prove to be inherently less proliferative than uranium/plutonium cycles. Since at least one

The concern over weapons proliferation problems has lately led to serious international consideration of alternative nuclear fuel cycles. Among these, cycles involving the breeding of the uranium-233 isotope from thorium, especially with provisions for its "denaturing" with ordinary uranium, are generally believed to show great promise for a nuclear energy future without weapons proliferation. In this article the author dashes cold water on the most optimistic of such expectations.—Ed.

such fuel cycle could be envisaged, they argued, it is important not to rush ahead with a plutonium economy before potentially less proliferative options are carefully examined.

The early stages of that closer examination have made it clear that thorium fuel cycles, including denatured ones, do not *qualitatively* alter the proliferation problem (either national or subnational) and in some respects offer more avenues for proliferation than once-through uranium cycles. The reactor-physics and safeguards considerations supporting this conclusion are somewhat elementary, but the scarcity of systematic analyses of them has lately generated much misplaced enthusiasm [6]: hence this summary.

Thorium and Uranium-233. There are two basic kinds of thorium cycles, both of which may breed fissile uranium-233 from fertile thorium-232, mainly via the intermediate product protactinium-233, which has a 27-day half-life. The first kind is the "pure" thorium cycle, a self-sustaining one relying on previously bred uranium-233 for fission neutrons to breed more uranium-233 in fuel consisting of uranium-233 mixed with thorium-232. Burnup of this fuel produces various isotopes, up to and including small amounts of plutonium formed by successive neutron captures.

From a weapons physics point of view, uranium-233 is similar and in some respects perhaps superior to plutonium-239, the classical material. They are roughly equal in reactivity, as shown by the nearly identical bare-sphere critical masses [7] of uranium-233 (16 kilograms at a density around 18.8 grams per cubic centimeter) and the delta phase of plutonium-239 (17 kilograms at about 15.8 grams per cubic centimeter). (Corresponding figures for the alpha phase of plutonium, at around 19.8 grams per cubic centimeter, are 11 kilograms for nearly pure plutonium-239 and 13 kilograms for "reactor-grade" plutonium produced at a burnup around 30 thermal gigawatt days per metric ton of uranium. Of course all these quantities can be reduced greatly—more than fivefold—by reflection and implosion in a nuclear explosive.) Broadly speaking [7], for fast neutrons the relative neutron yield is

$$^{239}\mathrm{Pu} \gg {}^{233}\mathrm{U} \geq {}^{235}\mathrm{U}$$

and the fission cross-section

$$^{239}\mathrm{Pu} \geq {}^{233}\mathrm{U} \gg {}^{235}\mathrm{U}.$$

These conclusions are relatively insensitive to contamination of the uranium-233 with traces of other uranium isotopes.

Because uranium-233 is about three times as reactive as uranium-235 (whose bare-sphere critical mass at 93.5 percent enrichment is about 50 kilograms), one might expect that a third as much of it would be required for a bomb. In fact the reciprocal of this ratio, the "substitution factor," is not 3 but typically 5 to 10 because a physically smaller core can be compressed more in a convergent implosion. (An incompressible solid spherical shell, if imploded, provides a pressure varying as the inverse fourth power of its radius [8].)

Ordinarily uranium-233 has a substantial neutron background because of (α,n) reactions with light-element impurities. With a significant chemical effort, which is not normal practice, these impurities can be greatly reduced so that the neutron background becomes lower than in weapons-grade plutonium, permitting use of a gun-type rather than an implosive assembly—a further option which may be easier than an implosive design. Both chemically and metallurgically uranium-233 is considerably more tractable than plutonium: it is not very pyrophoric and has one solid phase, not six. Its inhalation toxicity is considered to be about 70 times lower than that of plutonium-239, several hundred times lower than that of reactor-grade plutonium.

The only significant disadvantage of uranium-233 is that after production, various daughters of uranium-232 build up in it (peaking about 10 years after extraction), notably thallium-208. Some uranium-232 daughters emit intense and penetrating gamma rays, of which thallium-208 typically contributes more than half the total with its 2.6- and 0.6-megavolt emissions. Commercial handling of uranium-233, especially if it were more than a few days old (whereas aging for about a year is desirable for full decay of the protactinium-233 parent of the uranium-233), would require heavy shielding—of order twice as much as the gamma- and neutron-emitting recycle plutonium requires—to protect workers from overexposure. But if relatively small amounts of uranium-233 were being dealt with for relatively short periods outside the restrictions of prudent health-physics practice, shielding could be greatly reduced or even dispensed with.

A kilogram of uranium-233 produced at 46 thermal gigawatt days per metric ton of heavy metal burnup and 32 thermal megawatts per metric ton of heavy metal specific power, for example (corresponding to about 140 milligrams of uranium-232 per kilogram of uranium), then aged 90 days, would contain [9] about 82 mil-

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licuries of thallium-208. Total unshielded gamma dose from that kilogram at a distance of 1 meter would be of order one-quarter roentgen per hour. An American Physical Society working group [10] cites a uranium-232 content of order 200 to 1,000 milligrams per kilogram [11], implying maximum dose rates (after roughly hundred-day aging) of order 1 roentgen per hour from 1 kilogram at 1 meter. Such dose rates, though substantial, are hardly a matter of major concern to people likely to put the material to illicit use in the first place. It is also possible that supervisors of such use might neglect to tell workers of the hazard.

Because uranium-233 is an attractive weapons material and because chemical processing by methods thoroughly described in open literature can readily separate uranium-233 from thorium-232, the safeguards implications of a pure thorium cycle differ only in detail from those of a plutonium-239 cycle. The former offers no significant safeguards advantage over the latter—not even the ease of detecting uranium-233 by remote sensors such as door monitors, since modern techniques can also (we are assured) sensitively detect the high-burnup plutonium present in plutonium-based fuel cycles.

Making enough uranium-233 to set up a self-sustaining pure thorium cycle also requires that a mixed thorium/uranium-235 cycle first be operated for a very long time—typically several decades at least. Such mixed cycles breed surplus uranium-233 as a by-product. The neutrons needed to do this and to sustain fission in the mixed cycle must be derived from either highly enriched uranium-235 or fissile plutonium—both weapons materials. Thus the persistent initial phase of any sort of thorium cycle inevitably entails the presence, in some form, of weapons materials, incurring in some degree the safeguards problems that the thorium cycle was alleged to prevent. The denatured thorium cycle is one attempt, on paper, to reduce those problems to a more tractable level.

Denatured Thorium Cycles. The denatured thorium cycle—actually a mixed thorium-uranium or thorium-uranium-plutonium cycle—relies on the possibility of denaturing uranium-233, that is, making it into a form not directly usable for weapons, by mixing it with at least seven times as much non-fissile uranium-238 from which it cannot be chemically separated as plutonium could. This denatured fuel flows between two different kinds of reactors in different places.

First, "national" reactors—most or all of the total reactor population—are built in relatively dispersed sites which could be internationally administered but are more likely to be under national control (often of non-nuclear-weapons states). These reactors are breeders or advanced converters with good neutron economy, such as heavy-water, spectral-shift, or high-temperature gas-cooled reactors. They are fueled with a mixture of uranium-233, uranium-238, thorium-232, and perhaps uranium-235. (Liquid-metal fast breeder reactors appear unsuitable for this role: with normal designs their fuel would have to be too enriched in fissile isotopes for denaturing to work, and if the core were redesigned to permit denaturing, it would make too much plutonium-239 and not enough uranium-233 for the cycle to work properly.)

Regardless of the type of national reactor used, the thorium-232 would be largely in a blanket (according to most analyses) and the denatured uranium-233/uranium-238 (/uranium-235) fuel mainly in a central core. The thorium-232 and uranium-238 respectively produce uranium-233 and plutonium-239 of which part is burned in the reactor and part discharged in irradiated fuel. The *minimum* net production of plutonium-239—constrained by the need to have at least seven atoms of uranium-238 in fresh fuel per atom of uranium-233—is nearly 40 kilograms per electric gigawatt-year sent out: 5 to 7 times [12] less than with a light-water reactor, not zero.

Second, "secured" facilities are to be centrally sited in at most a few places under international control. Irradiated fuel from national reactors is then shipped to these centers and reprocessed. All fissile materials, including both plutonium and uranium-233, are recoverable, and in many analyses are assumed to be recovered, then used in various ways to breed more uranium-233 for denaturing and shipment back to the national reactors as fresh, isotopically denatured fuel. This breeding might be done in a thorium-232-blanketed breeder (for example, a liquid-metal fast breeder reactor) that burns plutonium-239 and some uranium-233 in its core. (The good neutron yield of the resulting uranium-233 in thermal converters might make the asymptotic ratio of national converters to secured breeders as large as 3 to 4.) The principle, however, is that no plutonium-239 goes off-site; the only fissile material leaving the "secured" facilities is denatured fuel.

In some other proposals, any excess plutonium-239 is burned on the secured sites in special burner reactors that lack fertile inventories. This yields energy from the plutonium but wastes neutrons; the system is not a net fissile producer. In a further variation due to von Hippel, the plutonium is never even extracted, but is discarded (under international controls) still mixed with the fission products. This makes immediate safeguards easier (the plutonium-bearing waste must still be protected from eventual recovery) and is not such a great economic loss because the high plutonium-236 and -238 content offers a disincentive to plutonium extraction and reuse [13]. In a plutonium-throwaway cycle—which can still be 5 to 6 times as uranium-

Multinational reprocessing plants would legitimize reprocessing and dissseminate its technology, somewhat like a hospital spreading disease, for thorium cycles unlike uranium cycles *require* reprocessing.

efficient as a once-through pressurized-water reactor—reactivity in fresh fuel going to national reactors is supplemented as needed, at least in the early stages, by makeup uranium-235. (This might be added as a feedstock at about 60 percent enrichment—whose critical mass is somewhat over twice that of fully enriched uranium-235—and then diluted with uranium-238 to a denatured level. Thus the total number of uranium-238 atoms in denatured fuel would be at least 7 times the number of uranium-233 atoms plus 4 times the number of uranium-235 atoms.) The secured facilities would then contain no reactors at all, but only reprocessing, enrichment, and fuel fabrication plants.

Regardless of the disposition of the plutonium within the "secured" sites, the important feature of these uranium-thorium cycles is that the denatured fuel that leaves those sites and forms an item of commerce is not directly usable for weapons nor, it is alleged, readily convertible to weapons material as mixed uranium-plutonium oxides, carbides, or nitrides would be. This allegation rests on the assumption that isotopic enrichment is not available to amateurs as chemical separation of fresh fuels presumably is. This assumption seems shaky, because "the technology to carry out such enrichment on non-economical, non-commercial scale is available in the open literature. This requires further evaluation" [14]. The relevant physical principles merit discussion here.

Wolf Häfele has stated [15] that "the construction of a set of crude centrifuges does not require unusual skills as long as efficiency and commercial competition are not the point." He added [16] that, to show this, a European centrifuge-builder once made in an American university machine shop (in about three weeks and with one technician) a crude centrifuge capable of respectably enriching natural uranium. (In practice, making a bomb from natural uranium with such centrifuges would require patience and tens or preferably hundreds of units because each has a relatively small mass flow.) But in interpreting this incident it must be recalled that:

- denatured thorium-cycle fresh fuel is not 0.7 percent enriched in the fissile isotope as natural uranium is, but rather about 12 percent—so that 85 percent of the separative work needed to attain high enrichment has already been done. (For example, at constant 0.25 percent tails assay, it can be calculated that 6.8 times less separative work is needed to enrich to a kilogram of, say, 93.5 percent product starting with 12-percent-enriched feed than with 0.71-percent-enriched feed.)
- the mass difference between uranium-233 and uranium-238 is two-thirds larger than the mass difference between uranium-235 and uranium-238. In gas-diffusion enrichment of hexafluorides this means the theoretical separation factor per stage would be 1.0072 (that is, enrichment from 0.12 to 0.935 in 286 ideal stages) rather than 1.0043 (in 478 stages), since diffusion velocities vary as the square root of molecular weight. With centrifugal enrichment, however, maximum separation factor varies exponentially with, and the separative power of a particular centrifuge varies as the square of, differences in molecular weight. Häfele confirms [17] that uranium-233 is three times (about $5^2/3^2$) easier to enrich than uranium-235—and separation factors for uranium-235 can be of order 1.2 to 1.5 or more per stage.
- as noted earlier, about 5 to 10 times less uranium-233 product is required than uranium-235.

These three considerations suggest that denatured thorium-cycle fuel is 100 to 200 times (= 7 x 3 x 5-10) easier to enrich to bomb usable levels than natural uranium—two orders of magnitude more than the difference between low-enriched and natural uranium. This factor implies that significant enrichment of denatured thorium-cycle fuel can be achieved not only with homemade centrifuges designed for this purpose by persons moderately skilled in the art but also with modified versions of commercially available medical ultracentrifuges. (These may have large volumes, speeds over 75,000 revolutions per minute, and accelerations over half a million gravities.) With patience, strategic quantities of uranium-233 could be accumulated with a few centrifuges (though a government would presumably use hundreds and make more uranium-233). Since the holdup in each centrifuge would be typically of order grams, the hard-gamma dose even for brief contact maintenance would probably be acceptable to those concerned (or at least to their supervisors)—though in the long run the concomitant enrichment in uranium-232 may increase the dose.

It could be argued fairly persuasively that conversion to uranium hexafluoride, centrifugal enrichment, and reconversion would be somewhat more difficult than extracting plutonium from fresh mixed-oxide fuel. But though different kinds of sophistication are required and the tasks are not strictly comparable, they do not seem to differ qualitatively in difficulty, especially for high-burnup recycle plutonium. Nor do the times required to perform both tasks necessarily differ by as much as an order of magnitude.

Denatured fuel, then, is not irrevocably denatured even for amateurs—let alone for governments. But the rest of the denatured thorium cycle also lends itself rather well to misuse. The national reactors have, of necessity, an excellent neutron economy. CANDU or similar reactors are likely in this role and, with their on-load refueling and slight excess of refueling-machine capacity, are well suited to clandestine introduction and brief irradiation of adequate amounts of fertile materials (thorium-232 or uranium-238) in a few channels for later clandestine reprocessing, perhaps in hot

It is important that thorium cycles not be euphorically and falsely advertised as a solution to the nuclear proliferation problem . . .

cells. In fairness, one must add that it may be easier to safeguard a reactor than a reprocessing plant; but the possibility of abuse remains, so that fully effective international inspection is still essential [18].

The spent fuel itself, rich in both plutonium-239 and uranium-233, and especially any blanket fuel, must be safeguarded against diversion and clandestine reprocessing—just what one is worried about with ordinary thermal reactors, with or without plutonium recycle or breeding. (Most nuclear power countries can today do laboratory-scale reprocessing, suitable for one or a few bombs, and could build a bomb–per–day crude reprocessing plant in a year or two for a cost one or two orders of magnitude less than the cost of a single power reactor.) Prompt reprocessing of irradiated thorium-cycle fuel—though it must cope with the high initial radioactivity—can also readily extract pure protactinium-233, which would then decay to isotopically pure uranium-233 with negligible gamma background [19]. And as with non-denatured fuel cycles, governments can disguise their own diversions as terrorist thefts, and can in dozens of effective but legal ways deceive international inspectors or make it impossible for them to do their job properly.

Further, the "secured" sites would indeed have to be secured—not only on paper—from both embezzlement and seizure of their extremely large fissile inventories. Though both embezzlement and seizure can be made more difficult by technical means, it appears to be impossible in principle to deny them altogether to a determined adversary. The formidable political problems of finding acceptable sites for multinational centers and protecting them from instability and expropriation would have to be overcome: most analysts who have carefully studied this problem consider it insoluble. Multinational reprocessing plants would legitimize reprocessing and disseminate its technology, somewhat like a hospital spreading disease, for thorium cycles, unlike uranium cycles, *require* reprocessing.

(If all these problems of the multinational centers were solved, one could also envisage a heavily spiked plutonium fuel cycle which would then have broadly similar problems. From a safeguards point of view the two cycles would appear similar—at least as regards small-scale bomb production; the plutonium cycle would probably offer more opportunities for rapid large-scale bomb production.)

It might be thought that centralization of reprocessing and of the use of pure fissile materials might make them easier to guard and assay; but it can equally be argued that this centralization makes the "secured" site a more valuable prize and a more vulnerable site to both accident and malice. It certainly makes the farflung net of dependent national reactors more vulnerable to all sorts of surprises.

Thorium and Nuclear Fuel Resources. Recent calculations—preliminary but probably fairly accurate—suggest [20] that no combination of national and multinational reactors that includes advanced converters can have a total conversion ratio greater than 1.0 (that is, be a net producer of fissile material)—except that a system using a one-to-one converter like a molten-salt reactor might in principle have a low breeding gain. The General Atomic Company also maintains that a carefully optimized system using high-temperature gas-cooled reactors can have a significant breeding gain [20]. Even breeder-breeder combinations would have a small fissile gain, typically of order two to three percent per year, and so would take many decades to come to equilibrium. They thus appear incapable of yielding the rapid gains in fissile inventory hoped for from advanced (and undemonstrated) plutonium-239 cycles.

If one assumes that the world will depend essentially forever on nuclear fission power on an enormous scale, this may be important—especially if one considers proneness to proliferation less important. If, however, one assumes more modest rates of growth in nuclear capacity or electrical demand, or views nuclear power as a parenthesis—even one of a century or two—then breeding gain is unnecessary, since efficient converters can stretch known uranium reserves far enough to suffice [5]. In particular, over the next 75 to 100 years, advanced converters can save as much uranium as plutonium-239 breeders. The advanced converters' relative insensitivity to the price of uranium expands reserves, and anxieties over security of supply can be cheaply relieved by stockpiling [21].

The mixed thorium/uranium-235 cycle has high initial requirements for uranium-235 and enrichment or for plutonium-239. These large first-core requirements can produce a dynamic materials-flow problem if one tries to set up such a fuel cycle quickly. This is analogous to the problem of rapid construction of fast breeders; a plutonium shortage for initial cores [22] is liable to arise unless many thermal reactors are also built and run in tandem with the breeders for many decades to produce their plutonium. The combined population of fast and thermal reactors is then likely to run short of uranium-235 (assuming this to be in short supply to start with). Starting with breeder cores of low specific plutonium inventory also means low breeding gain, thus uranium shortage, and substituting highly enriched uranium for scarce plutonium still does not take the pressure off of uranium supplies.

The reason this problem cannot be evaded points up an important feature of thorium fuel cycles—a feature so simple it often goes unrecognized. Using thorium does not

. . . a problem that is the most compelling reason to reject all forms of nuclear power in favor of fission-free energy strategies.

magically expand the supply of nuclear fuel, only of *fertile* material, of which we already have a great deal in the form of uranium-238. No fertile material, whether it be uranium-238 or thorium-232, can be bred into a fissile material save by neutrons. These, the coin of the nuclear realm, must be derived ultimately from uranium-235 (either directly or via bred fissile materials such as plutonium-239) [23]. It is therefore the supply of uranium-235 in the ground that poses nuclear fuel constraints. The only sense in which using thorium helps with the nuclear fuel problem is that thorium-232 can be bred with thermal neutrons (and can then fuel efficient thermal converters), whereas uranium-238 can be most efficiently bred with fast neutrons. The former process may be more convenient, though the latter has higher neutronic efficiency—a property not wholly unlinked to its relevance to bombs. And the fast-breeding ability of uranium-238 is irrelevant if, as appears to be the case, the available uranium-235 is ample [5] when used in thermal converters.

People who wish to ascribe magical properties to thorium cycles should also remember that the above description of a denatured thorium cycle is theoretical. No such cycle has operated anywhere, though there has been minor use and reprocessing of thorium fuel at pilot scale. Dissolution and extraction are somewhat harder than for low-burnup uranium dioxide fuel [24]. It is possible that actual behavior of a thorium cycle might depart significantly from the above results of preliminary calculations, or that unexpected technical problems might arise as they have done persistently with moderate-burnup plutonium cycles. It does seem rather late in the day to start with a whole new set of fuel physics and chemistry. Of course, just the same could be said of high-burnup plutonium cycles—which, unlike their low-burnup predecessors that have rested on generous military subventions throughout their establishment, are now having to pay their own way, and are finding the burden of fuel-cycle investments unsustainable. Thorium cycles would have the same problem from the start: the visibility of full fuel-cycle costs could be a most ineluctable deterrent.

Among the criteria that Cochran and others proposed [5] as a minimal and partial basis for acceptability of commercial fuel cycles is that their

"development and commercial utilization of the technology by a nonnuclear weapons state leaves that state no closer to a nuclear weapons capability than would be the case if all its nuclear power were derived from low-enriched uranium fueled reactors operating in a once-through fuel cycle . . . and with verified spent fuel storage in secured international facilities" [25].

It appears very doubtful that denatured thorium cycles could meet this criterion. Certainly they cannot greatly improve the present safeguards situation; and for reasons similar to those set out above, Theodore Taylor has recently described the notion that they can as "a snare and a delusion" [26]. A more mature assessment by the technical community of the grounds for his skepticism will probably lead many to share it. And he and I would both emphasize that the safeguards/proliferation problem has *no technical fix*. It is partly, even predominantly, a *political* problem. Facile assumptions [6] about technical fixes or near-fixes will not solve the political problem and might well make it worse by giving a false sense of security.

Thorium cycles have had the misfortune to be attacked both by plutonium advocates (for competing with their favorite technology) and by nuclear critics (for having the potential, in the hands of the uninformed, to give nuclear power an undeserved new lease on life) [1]. Neither basis for attack is a sound basis for public policy. Yet both contain an important lesson. Advocates of nuclear power should learn that there is no need to rush into the plutonium economy [27], and that a wide range of alternative fuel cycles [28] may offer attractive substitutes for it later. It is equally important that thorium cycles not be euphorically and falsely advertised as a solution to the proliferation problem—a problem that is the most compelling reason to reject all forms of nuclear power in favor of fission-free energy strategies [29].

1. This formulation is due to Lew Kowarski. I am indebted for discussions and correspondence to him, Tom Cochran, Floyd Culler, Warren Donnelly, Peter Fortescue, Sir Brian Flowers, David Hafemeister, Walt Patterson, Ted Taylor, and Frank von Hippel, many of whom suggested significant improvements in an earlier draft. I alone am responsible for the results.

2. See, for example, references 3 and 5; A. B. Lovins, *Soft Energy Paths: Toward a Durable Peace* (New York: Harper & Row, 1979), especially Chap. 11; International Technology Project, Institute of International Studies, University of California, Berkeley, *Non-Proliferation and Nuclear Waste Management*, Contract AC6AC725 (Washington, D.C.: U.S. Arms Control & Disarmament Agency, 1977); A. Wohlstetter et al., *Moving Toward Life in A Nuclear Armed Crowd?*, ACDA/PAB-263 (Los Angeles, Ca.: Pan Heuristics, 1977); Wohlstetter and T. B. Cochran, respective Proofs of Evidence for the summer 1977 Windscale inquiry (U.K.).

3. H. A. Feiveson and T. B. Taylor, "Security Implications of Alternative Fission Futures," *Bulletin* 32:10 (December 1976), 14-18, 46-8.

4. Of course, uranium cycles can be isotopically denatured too—as is the conventional once-through low-enriched uranium cycle.

5. T. B. Cochran, R. E. Train, F. von Hippel, and R. H. Williams, "Proliferation Resistant Nuclear Power Technologies: Preferred Alternatives to the Plutonium Breeder," including additional statements by T. B. Cochran and R. E. Train, part of the report of the LMFBR Review Steering Committee (R. Thorne, Chairman), report to the President, April 6, 1977.

6. See, for example, Sir Fred Hoyle, *Energy or Extinction?* (London: Heinemann Educational, 1977), pp. 50-1.

7. H. C. Paxton et al., "Critical Dimensions of Systems Containing U^{235}, Pu^{239}, and U^{233}," TID-7028 (Los Alamos Scientific Laboratory, June 1964); R. W. Selden, "Reactor Plutonium and Nuclear Explosives"

(Lawrence Livermore Laboratory, Nov. 1, 1976); *Reactor Physics Constants*, ANL-5800 (2d ed.), Argonne National Laboratory, 1963.

8. E. Teller, in S. A. Blumberg and G. Owens, *Energy and Conflict: The Life and Times of Edward Teller* (New York: Putnam, 1976), Appendix.

9. M. J. Bell and J. P. Nichols, "Penetrating Radiation Dose Rates and Shield Requirements in Fabrication of Fuels Containing ^{233}U and High Exposure Plutonium," in *Sol-Gel Processes and Reactor Fuel Cycles*, CONF-700502 (Oak Ridge National Laboratory, 1970), pp. 74-84. For dose vs. aging, see reference 10, p. S 154, figure 11.

The BNL paper cited in reference 17 states on page 23 that for uranium-233 dioxide with 1 gram of uranium-232 per kilogram, a 100-roentgen dose will be accumulated in 3 days, 5 hours, and 2 hours respectively, if an individual is 1 foot from 30 kilograms of uranium dioxide aged 0, 10, and 20 days since chemical separation.

10. American Physical Society, Study Group on *Nuclear Fuel Cycles and Waste Management*, *Reviews of Modern Physics* 50:1 (Jan. 1978), Part II, p. S 154.

11. See reference 10, p. S.171, citing T. Pigford and C. Yang, "Thorium Fuel Cycles," UCB-NE3227 (Berkeley: University of California, June 1977). The authors calculate recycled uranium from a high-temperature gas-cooled reactor as about 500 milligrams per kilogram, but predict as high as 9 grams per kilogram for a uranium-thorium light water reactor fuel cycle.

12. APS Study Group (reference 10, p. S 155) says a factor of about seven in idealized fuel cycles, but notes that about three is possible in "more practical designs."

13. APS Study Group (reference 10, p. S 171). The plutonium-236 and-238 are formed largely from neptunium-237.

14. APS Study Group (reference 10, p. S 102, S 156).

15. W. Häfele, "Non-Proliferation of Nuclear Weapons" (Laxenburg, Austria: International Institute for Applied Systems Analysis, Dec. 1976), p. 10.

16. W. Häfele to Lovins, Feb. 16, 1977.

17. W. Häfele, in *Argumente in der Energiedtskussion: 1. Schnelle Brüter: Pro und Contra* edited by H. Matthöfer (Necker-Verlag, Villingen, Oct. 1977), pp. 44-45.

For a discussion of separation factors for uranium-233 *vs* uranium-235, see Brookhaven National Laboratory, "Preliminary Safeguards Analysis of Denatured Thorium Cycles," file #5.8.13 (Upton, N.Y.: BNL Technical Support Organization, Nov. 10, 1976). An addendum (July 14, 1977) calculates that five kilograms per year of 90 percent uranium-233 can be separated (at 1 percent tails assay) from 49 kilograms of uranium per year that is 10% uranium-233 and 90 percent uranium-238 with an ideal cascade of 43 centrifuges, each having a capacity and a separation factor, respectively, of 3.0 kilogràms of separative work per year and 1.10 for uranium-235 (8.3 kilograms of separative work per year and 1.17 for uranium-233). Gas centrifuges with better performance than this and costing around $10,000 or less are described in the open literature.

18. APS Study Group (reference 10, p. S 102) states: "It must be remembered that with *any* denatured fuel cycle, international inspection is still essential in guaranteeing that fresh fuel and/or natural uranium are not being diverted to small enrichment facilities, that reactors are not being misused to produce plutonium, and that small non-safeguarded separation facilities are not operated in addition to those at international centers. Such inspection goes beyond present IAEA agreements but must become part of any future political arrangements which institutionalize denatured fuel cycles."

The International Atomic Energy Agency report of June 8, 1977 to the IAEA Board of Governors, GOV/1842, calls attention in its Annex to the serious and, so far, unsurmounted difficulties of effectively safeguarding both reprocessing plants and on-load refueling reactors.

19. APS Study Group (reference 10, p. S 154) referred to the prepublication preprint (VIII. F 1) to "a relatively simple chemical separation." H. C. Ott states (*Power Engineering*, Nov. 1977, p. 28) that the minimum protactinium-233 assay—that characteristic of a pressurized water reactor—is 3.8 percent of the fissile uranium assay.

20. F. L. Culler, Jr., to Lovins, May 1977; the calculations, mainly by Argonne National Laboratory, are to be published in connection with supporting research for the International Fuel Cycle Evaluation. See also C. L. Rickard (General Atomic Co.), "The Thorium Fuel Cycle," AIF Fuel Cycle Conference, New York, March 5-8, 1978.

21. F. von Hippel and R. H. Williams have calculated that each ten years' worth of uranium stockpile bought at $40 per pound of U_3O_8 incurs a carrying charge (at 16 percent per annum) that raises the delivered price of nuclear electricity by an amount ranging from 0.9 percent (once-through PWR) to 0.2 percent (heavy water reactor with uranium-233 and-235 recycle and throwaway plutonium) (H. A. Feiveson, "Proliferation Resistant Fuel Cycles," *Annual Review of Energy* 3 (1978), 391, Table 8).

22. L. Grainger, *Energy Policy* 4 (Dec. 1976), 322-9; D. Merrick, *Nature* 264 (1976) 306-8.

23. Surplus neutrons might in principle be available from sources other than pure fission cycles—for example, spallation reactions in accelerators, or thermonuclear or near-thermonuclear reactors—but such sources are neglected here because of their uncertain or unfavorable feasibility, lead times, energy balance, and economics.

24. APS Study Group (reference 10, pp. S 36, S 153).

25. Verified fresh-fuel storage would also be required to prevent diversion to clandestine enrichment facilities or production reactors.

26. T. B. Taylor to Lovins, Sept. 30, 1977.

27. S. M. Keeney et al., *Nuclear Power: Issues and Choices* (Cambridge, Mass.: Ballinger, 1977); H. A. Feiveson et al., "The Plutonium Economy: Why We Should Wait and Why We Can Wait," *Bulletin* 32:10 (Dec. 1976), 10 ff. Feiveson, "Proliferation Resistant Fuel Cycles," *Annual Review of Energy* 3 (1978), 357-94. See also references 2 and 21.

28. See reference 27, Cochran [5], APS Study Group [10]. Unfortunately the discussion of alternative fuel cycles may be temporarily derailed by sophistical discussions of plutonium cycles based on breeder reactors that do not breed.

If the original goal of high breeding gain is to be abandoned (see, for example, W. Marshall, "Nuclear Power and the Proliferation Issue" (London: United Kingdom Atomic Energy Authority, Feb. 1978), fast reactors become unnecessary; and if it is felt desirable to incinerate stocks of plutonium (and perhaps other actinides), that are already separated, this can be done in low-power-density thermal reactors with a non-fertile matrix. Spent fuel not yet reprocessed can be disposed of irretrievably (one hopes) in the manner intended for vitrified high-level wastes. As for plutonium not yet generated in thermal reactors, the opportunity of generating it in order to be able to build non-breeding fast reactors in which to incinerate it can simply be foregone.

L. Kowarski has aptly remarked that the Marshall proposal reminds him of the entrepreneur whose herd of cows gave milk copiously while there was a glut of it and Europe was already sinking under a mountain of powdered milk. He said, "Don't worry; with high-pressure salesmanship I shall dispose of all my milk anyway." On being told, however, that the milk was full of cholesterol and might hence be dangerous to drink, he said, "That is more serious. But I have a solution: I shall simply feed the milk to the cows. They can be trained to drink vast quantities of it!"

29. See, for example, A. B. Lovins [2]; for a compendium of critiques and responses, see U.S. Senate, Select Committee on Small Business and Committee on Interior & Insular Affairs, *Alternative Long-Range Energy Strategies*, 2 vols. (Washington, D.C., U.S. Government Printing Office, 1977), condensed by H. Nash in *The Energy Controversy: Soft Path Questions and Answers* (San Francisco, Ca.: Friends of the Earth, 1979); Lovins, "Re-Examining the Nature of the ECE Energy Problem," ECE (XXXIII)/2/I.G. (Geneva: U.N. Economic Commission for Europe, Feb. 20, 1978); Lovins, "Soft Energy Technologies," *Annual Review of Energy* 3 (1978) 477-517.

Universities should unite and refuse to contract with, or take gifts from, oppressive foreign governments.

DAVID FRISCH

Human rights and university contracts

By reasserting the United States government's fundamental concern over international human rights, the Carter administration and Congress have prevented much acute suffering and have promoted liberalizing tendencies in Chile, Indonesia, Iran, the Philippines and elsewhere. Nevertheless, public attention is devoted more to our government's inconsistencies in opposing human rights violations than to its success. Inconsistencies will naturally occur, since a government must often yield to demands for international, political, economic and cultural arrangements. We wisely do not break off diplomatic relations with Argentina, for example, because we must be as concerned with the spread of nuclear weaponry as with human rights.

Like governments, individuals also have various responsibilities in their interactions with foreign agencies, and no uniform code can reasonably be urged on them either. The American public health expert asked to advise in Tehran or Peking, the basketball player to compete in Havana or Capetown, the dancer to perform in Santiago or Moscow must evaluate the human rights situation for himself.

These difficulties for governments and individuals require that some organizations represent us nationally (though not governmentally) and support minimal human rights in direct dealings with foreign governments. Without some nation-wide formal commitment to minimal human rights we will probably not address these problems except occasionally. Furthermore, without a guiding system, we are likely to treat them ineptly or turn away with bad excuses.

Amnesty International, the International Commission of Jurists, and the International League for Human Rights have reliably documented the existence of human rights violations in many countries. The Amnesty International 1977 International Report provides detailed information on 116 countries, including the status of remedial efforts.

In addition, the Commission on Human Rights of the Organization of American States has worked effectively in a limited area, as has the U.N. Human Rights Commission.

Supplementing these international organizations, an American institution, The Investor Responsibility Research Center, evaluates without advocacy how social and public policy issues, including human rights, affect major corporations and institutional investors.

Lastly, the annual report on human rights by our State Department to the House and Senate Foreign Affairs Committees reviews fully those 105 countries to which federal economic assistance was given or which were proposed for security assistance.

Since the resources for making decisions on international human rights questions are fairly well developed, why have the universities and the churches, those nongovernmental institutions most apt to feel responsible for international human rights, not opposed systematically the most horrible abuses? There are several reasons:

- the problems are distant; facing them clearly requires an imagination and conscience as rare in churches and schools as elsewhere;
- the strong fear in academia of following worthy causes to zealotry feeds its feeling of impotence about affecting the behavior of repressive foreign governments; and
- the few who have considered action are bewildered about how any specific, limited and unprejudiced policy can be followed by our religious or educational institutions.

Universities, rather than organized religions, are the nongovernmental organizations most likely to accomplish anything; the universities have more to lose from inaction, and can exert a greater influence on foreign governments.

The universities' special responsibility for human rights arises from their commitment to a humanistic tradition in the application of knowledge to public affairs.

Closely related to this is the universities' practical obligation to encourage open discussion, particularly of contracts made with repressive governments and gifts received from them. Whereas the individual public health expert advising in Tehran can overlook the Shah's systematic torture, the university contracting for the same work must justify itself publicly to its faculty and students. When the university administration and faculty avoid these issues, their moral leadership weakens. Similarly, by facing them the universities can engender a sense of responsibility and humane purpose both in their students and our larger society.

Our universities' position is particularly strong because many countries buy intellectual and moral support from them. Water resource studies, public health training, new science laboratories and management programs and even whole universities are often supplied to developing countries. Though these services are also available through private consultant contracts and governmental programs, the imprimatur of formal American university sponsorship is quite valuable to the governments of many developing countries because it visibly endorses their

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enlightenment both at home and in the rest of the world.

Thus, contrary to many popular suppositions, our universities have a good position for bargaining over human rights abroad. For example, the University of California effected the release of some 30 Chilean professors from prison by threatening to break off joint research contracts. Indeed, if our universities united for minimal human rights as nimbly as they did to oppose the admission of foreign-trained medical students as a condition for per capita support payments, they would probably find most oppressive foreign governments quite responsive to pressure.

The proposal here is that American universities unite in refusing to contract with, or take gifts from, foreign governments that systematically deny either of two basic freedoms: freedom to emigrate and freedom from torture. *The human rights issues must be limited strictly to emigration and torture.*

Even two very limited responsibilities may overtax our universities, unused as they are to consciously organized moral leadership. If so, the irreducible single human right that universities should assume responsibility for is freedom from torture.

A natural reaction against a restrictive, formal university position is that universities have a responsibility to bring knowledge to all people. I believe, however, that the obligation to increase knowledge is greatly outweighed by the obligation to combat violations of human rights. Indeed, when a university functions by ignoring or occasionally even suppressing important truths, knowledge loses much of its meaning and value.

A related argument is that cultural exchanges fostered by university contracts are one of the main hopes for liberalization of repressive regimes. This may be true, but cooperation and refusal to cooperate are both useful, and what may be right for the individual public health expert, for the U.N. Food and Agriculture Organization, the Olympic Committee or the U.S. National Aeronautics and Space Administration is certainly wrong for universities.

Another strong fear is that in evaluating human rights we will inevitably censure agencies of our own government, and thereby politicize our universities. Our relationship with our own government can and should differ from that with foreign governments. In those countries sanctioning chronic torture or denials of emigration, representatives of American universities usually cannot discriminate effectively among the individuals and factions of different agencies. Even if such distinctions were possible, they would not justify a contract. Unfortunately, we probably must choose between ignoring the injustice or a total boycott. By contrast, in our own country we are citizens committed to participate, to act as if we know good motives from bad. Our institutions. must reflect necessary compromises.*

The practical criticism can be raised that we would tear our universities apart by disputihg absolute moral positions. Furthermore since terrible injustice exists everywhere, how can we limit our concerns so as to distinguish between one country and another without being forced to refuse relations with all?

Although the universities could not address more than a few of the world's terrible injustices without soon losing their scholarly identities, taking serious responsibility for only two aspects of one limited but central moral issue would not harm them. Rather, it should enhance their prestige.

*Amnesty International chapters are not allowed by their own rules to work on behalf of individual prisoners in their own countries, but are assigned other countries as their targets of protest. Their Moscow Chapter was harassed for protesting human rights violations in Sri Lanka, among other countries, and not those in the Soviet Union.

In order to show that practical distinctions are possible, we will now discuss the two human rights violations of preventing permanent emigration and of systematic torture. These injustices are universally condemned, and they can be defined practically. The existence of these violations can be established and reasonable country-by-country distinctions can be made.

Wholesale prevention of permanent emigration by a government is deeply inhuman; it is the modern "peculiar institution" of slavery. Nevertheless, an objection can be raised that the right to emigrate is meaningless without a corresponding right to immigrate—what's the use of being able to leave if there's no place to go? Fortunately, countries usually exist for at least some people to go to permanently, even though their access may be severely limited by their accomplishments, and a long wait may be required. Free immigration for all is a near-utopian goal; free emigration for the desperate is much more modest and would relieve intense intellectual and moral suffering, the particular concerns of universities.

Our universities should also attend to the even worse injustice of systematic physical or mental torture. Torture is the most brutal human activity. While it is somewhat harder to get reliable information about torture than emigration, we can easily get enough to warrant an investigation. In advocating the rights of political prisoners, Amnesty International and the International Commission of Jurists investigate charges of systematic torture, establish facts and report them without exaggeration. The U.N. Human Rights Commission has also occasionally established the existence of systematic torture in some countries. The denial of access to representatives of these organizations, which occurred in the Soviet Union, Iran and Chile, itself compellingly indicated what went on in those countries.

Many experienced and sympathet-

Our universities have a good position for bargaining over human rights abroad; one university, for example, effected the release of 30 Chilean professors by threatening to break off joint research contracts.

ic people are reluctant to adopt an absolute position on torture. They believe occasional torture has been practiced by almost every government, and that even systematic torture is so widespread that no country can be isolated. These two assertions will be discussed separately.

Torture will probably be practiced *occasionally* by local policemen, but civilized society must expose these occasional acts, redress the injured and punish the torturer. Our federal government so acted by intervening in the Castroville, Texas, police torture case.

Another argument commonly employed to prove the impossibility of establishing general rules is: "Would you have had European universities refuse to make research contracts with us because of allegations that our CIA or DOD sponsored torture in Vietnam?" Of course, they should have investigated the charges and on substantiation or denial of access have firmly refused! Such examples are only moral embarrassments for past neglects, rather than logical embarrassments for future actions.

The argument still remains that torture in particular is so widespread that no practical line separates guilty from innocent countries. On the contrary, we can distinguish clearly if we adopt certain standards. The charges should be of explicit violations, should be against countries with which contracts are current, and should be investigated using established procedures. If systematic torture or denial of emigration is found, "systematic" being partly defined as involving more than one case a year, contracts should be suspended for a specified period in which no further abuses occur.

To illustrate such practical distinctions, I submit my own evaluations of a representative sample of countries.

Countries are listed in three groups. The charge of denial of emigration will be indicated as (e) and that of torture as (t).

In the first group are easily approvable countries, like Great Britain (t), India (t) and Israel (t). These nations have active parliamentary oppositions that advocate the prosection and punishment of torturers. These governments' innocence of systematic torture is attested by their compliance with requests for international monitoring; Israel, for example, allows Red Cross representatives to visit any detainee in their prisons after two weeks. A remarkably large number of countries without democracy oppose systematic torture and are responsive to enquiry, such as Kenya (t) and Pakistan (t).

The second group contains borderline cases, countries that have improved recently, such as Chile (e,t), Indonesia (t), Iran (e,t), South Korea (t), the Philippines (t), South Africa (e,t) and Taiwan (e,t). Our universities should accept only contracts from these countries and emphasize that reversion to former practices will be grounds for breaking contracts.

The third category includes nations we hope ultimately to influence but are presently pessimistic about. Examples are Argentina (e,t), China (e), Cuba (e), Guinea (e, t), Iraq (e,t), Morocco (t), and the Soviet Union (e,t). The intractability of most of these comes from ideology. However, even the most doctrinaire and powerful nations may well respond to pressure for a limited change. The Soviet Union, for example, may drop the forced use of narcoleptic drugs fairly soon because of pressures from western doctors and psychiatrists, whereas they will not yield on the emigration issue.

Since little demand exists for development contracts with communist nations, to reject contracts with these nations pending their liberalization on torture or emigration would not sufficiently pressure them. Even if we restrict our conditions to "no torture" alone, we would still be unable reasonably to verify or refute charges against most of these nations because the denial of access is part of the same policy that forbids emigration.

As a real test of impartiality, our universities should collectively decide not to sign contracts with China

Looking back a few years ago, we see that faculties and administrations did not think through any general positions beyond those of academic freedom and an open campus.

because it does not allow free emigration, but should not now object to individual universities' signing contracts with the Philippines, contingent on its continued improvement.

I repeat that these are evaluations of two narrow issues only, not of the whole human rights spectrum. Anyone sensitive to human rights who has followed the news over recent years will have difficulty accepting contracts with Chile, Indonesia, Iran, the Philippines, South Korea and Taiwan, but a political prisoner in these countries will almost certainly not be tortured. Nor will he be denied emigration if not brought to trial, and he will be allowed to emigrate after serving a sentence, though he may be held under otherwise horrible conditions. I repeat that setting minimum conditions does not endorse these countries as acceptable in anything else, or inhibit individual universities from promoting other human rights.

An inter-university committee that makes such judgments systematically will not find its job trivial—South Korea, for example, may at the moment of writing be moving backwards; on the other hand, this job will not be more difficult than most serious decision-making. Much good will be done, and little university income will be lost.

Looking back at the discussions of contracts on our campuses a few years ago, we see that the faculties and administrations did not think through any general positions beyond those of academic freedom and an open campus. A substantial national debt was incurred when students in their politically formative years learned of the reluctance and inability of these leaders even to try to formulate the large responsibilities of universities.

This failure formally to address significant questions should weigh heavily on us after the Nixon years. We might easily have lost our liberties without the categorized responsibilities of Congress and the courts. The framers of our marvelous constitution were not embarrassed to encode a very limited but absolute morality in order to help control an unforseeable future.

Such a limited morality could also be formulated among our universities by drawing a clear human rights line beyond which they will not enter into contracts or take gifts.

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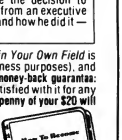

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Mass science will survive political change and influence China's modernization.

ROBERT C. HSU

Mass science in China

"Mass science" played an important role in China's science policy and development strategy during the Cultural Revolution decade (1966-75), yet its meanings, implications and limitations in the Chinese context are seldom understood by western scientists, scholars and even seasoned observers of Chinese science and technology. For example, at an international symposium on science and technology in China and India held in Lund, Sweden, in May 1978, there was much evidence of this lack of understanding. Both sympathizers and critics of China's mass science tended to take the term literally. One critic pronounced it to be a failure because few articles written by the "mass scientists" had appeared in China's scientific journals such as *Scientia Sinica*, and no major scientific discoveries had been made by the practitioners of mass science, that is, the peasants and workers.

The purposes of this paper are threefold:

- to clarify this confusion by defining mass science as precisely as possible;
- to present a balanced assessment of the uses and abuses of mass science in China during the Cultural Revolution decade (1966-75); and
- to analyze the future of mass science in China.

What does mass science mean in China? A scientist at the University of Communications in Sian defined it for me as "scientific experiments made by the masses." I would add that the bulk of the experiments are production-related, made by the peasants and workers in their attempt to achieve technological "self-reliance." Even experiments seemingly unrelated to production tend to be service-oriented such as experiments in herbs, earthquake prediction, and sanitation, etc. In this paper I shall use the term to denote the research and development activities carried out by the peasants and workers in areas which are related to the production of goods and services. I shall use the term "professional science" to denote the higher-level R&D conducted by trained scientists and experts in areas both related and unrelated to production. Note that the people engaged in mass science are not "amateurish" in the western sense of the word because their activities are related to their vocation and are remunerative. Nor are they "professional" in the western sense because they do not have adequate prior training for, and proven expertise in, their experiments.

In agriculture, peasant activities in "scientific farming" are considered to be mass science. Examples are the development of high-yielding varieties, the selection of better seeds, and the use of insects to eliminate harmful insects, etc. Here agricultural mass science is akin to agricultural extension services in other developing countries in that it aims at the development and/or the diffusion of new techniques. It differs from extension services in that the experiments and diffusion are carried out by local peasants instead of outside experts. In industrial production, any technical experimentation and innovation made by the production workers themselves constitutes mass science. Examples include innovations which cut down the use of materials, experiments to increase the level of automation in a certain production process, and learning to solve technical problems in production, etc.

It should be clear from the above that mass science is not necessarily science in the strict sense of the word. However, the use of the term science does help to give the peasants and workers a sense of participation in the nation's development in science and technology, to instill in them a more scientific and technical attitude in thier work, and perhaps also to raise enthusiasm for the study and diffusion of science proper. To criticize mass science for failing to contribute to the frontier of scientific knowledge is tantamount to criticizing China's barefoot doctors for failing to find a cure for cancer, or for failing to make a medical breakthrough. The problem with western critics of China's mass science is that they tend to look at China's policies from their own country's point of view, assuming the same circumstances and the same objectives for China's science policy. They are also zealous guardians of their professional definition of science, permitting no "unscientific revisionism." This does not mean that mass science as practiced in China is above criticism, as we shall see below.

Mass science was promoted during the Cultural Revolution in the late 1960s, and was particularly emphasized in the first half of the 1970s by the Gang of Four in their efforts to promote proletarian technological self-reliance as well as the dictatorship of the proletariat over bourgeois scientists. Thus, mass science had its technological as well as political aspects. They interacted to produce both positive and negative results.

On the positive side, mass science has helped to fill a gap which has existed in China as in all other developing countries—the severe shortage of trained scientists and technicians. Because of that shortage, the alternative to mass science open to many production units

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would have been no science at all. This is analogous to China's promotion of barefoot doctors for rural health care because full-fledged physicians are often unavailable. By promoting mass science, China has encouraged millions of passive peasants and workers to become actively involved in improving their own production techniques. By requiring the bourgeois scientists to participate in production work and help train the mass scientists, the Chinese leaders have broken down some of the barriers between the professional scientists and the laborers and made the former more aware of the urgent needs of the society.

Mass science was particularly important in agriculture. It has helped to create a national network of experiment stations in the rural areas which have contributed greatly to the development and popularization of new agro-techniques. In this regard, China's policy of relying on peasant-scientists for "scientific farming" has, in my opinion, important advantages over the policy of other developing countries to rely on outside experts. First, it would have taken China much more time to train a large number of extension workers. Second, local peasants are more familiar with local conditions. Third, unlike outside experts, local peasants have vested interests in raising the agricultural productivities of their own collectives. The built-in incentives for local peasants to raise agricultural productivity work in the following ways:

- higher output means more income for the collective, and hence more income to be distributed to all members of the collective, including the innovators;
- the innovators and efficient peasants are likely to receive more work points for their work and thus a larger share of the higher collective income;[1]
- the social recognition and prestige accorded by the rural communities to outstanding local peasants are very important in China and serve to reinforce the material incentives mentioned above.

In industries as well, the production workers often have vested interests which experts do not have in making their work as safe and as labor-saving as possible. This has provided a favorable condition for mass science. For example, in the First Cotton Textile Factory in Shihchiachuang, Hopei, I met a worker who developed a mobile electric chair for the spinning workers. Previously these workers literally "walked" more than 15 kilometers a day attending the machines. Now they can accomplish the same or even a larger amount of work sitting on the mobile chair (which is aptly called the "vehicle of happiness"—*hsin-fu che*). Not only was the innovator elected a model worker with her picture prominently displayed in the plant and sent to Peking to attend a national industrial conference, but perhaps more important, her innovation is reducing her own fatigue day in and day out. I have also observed several other cases of innovation which either reduce the labor intensity of work, or increase the safety of a particular operation. Incidentally, it should be obvious from the above that, compared with workers in non-socialist countries, the Chinese workers have more incentives in developing and/or popularizing labor-saving innovations because they do not have to fear for their jobs due to automation.

All of this does not mean that peasant- and worker-scientists are superior to, and can supplant, professional scientists, and that a country's agricultural growth and industrial innovation can be maximized with mass science alone. For the national political leaders to suggest so is to exaggerate the power of mass science and to mislead the public. Worse still, to promote mass science, not on pragmatic or economic grounds but on ideological grounds is to commit the sin of dogmatism. Unfortunately, this became the case during the Cultural Revolution decade (1966-75), initially under the ideological inspiration of Mao Tsetung but increasingly under the political influence of the Gang of Four who controlled the mass media. During that decade, although mass science in itself was useful in ways described above, it was abused by the radicals for both ideological and political reasons, with serious consequences which offset or more than offset its positive results.

Ideologically, it was claimed that peasants and workers possessed potential for great scientific innovations for two reasons. First, because of their lack of bourgeois education and influence (that is, being "poor and blank"), they are not inhibited from attempting difficult experiments and bold innovations which bourgeois scientists "know" are impossible. Second, because of their class background, they are hard-working, selfless, and eager to contribute to the country's socialist construction. These potentials can be realized if the peasants and workers are given "relevant" training, opportunities to experiment and innovate on the job, and most important, political support by the party leadership. On the other hand, it was believed that bourgeois scientists and experts, unless thoroughly re-educated politically, can be a hindrance to China's progress and self-reliance in science and technology, for the following reasons:

- they are selfish because of their class background, attempting to monopolize scientific and technical knowledge and skills for their own interests;
- they are conservative in their work because they believe in western supremacy in science and technology, and dare not attempt what foreign experts have said are impossible;
- they do not trust the masses and have no confidence in their latent creativeness.

The political implication of this ideology is that politics should be

China's policy of relying on peasant scientists for 'scientific farming' has important advantages over the policy of other developing countries to rely on outside experts.

"in command" in scientific and technical work, for if political work is done well, the scientists' thought and work-orientation should be changed and their scientific and technical work should also be improved.[2] This suited the interests of the radicals well, for they were intent on strengthening their own political power by weakening all potential opponents or rivals, including the scientists and intellectuals who were better educated and less manipulatable than the masses.

Because of these ideological and political motivations, the radicals adopted the following measures to promote science and technology. "Open door research" in which people without prior training or education could participate, was advocated as an important part of mass science. The universities were closed for a number of years after the beginning of the Cultural Revolution in 1966. After they were reopened, admission was based on political recommendation from work units rather than on academic merits. Faculty and students alike spent much of their time on the farms and in the factories. The technical achievements of the masses were glorified and credited to mass science while those of the experts were deliberately ignored in accordance with the radicals' philosophy of science: "all innovations are created by the laborers in their production struggle and scientific experiments."

As a result of this, the quality of education was lowered, high-level research and development disrupted and discouraged, and the professional scientific community demoralized. Predictably, the gap in science and technology between China and the industrialized countries widened.[3] Furthermore, I believe that in the end mass science itself also suffered in such a highly-charged ideological and political environment for two reasons:

- mass science tended to be evaluated, justified and supported, not on the basis of its economic or pragmatic results, but on the basis of its ideological correctness and political values; and
- beyond a certain level, further advances in mass science became increasingly difficult because there was little high-level research and development for it to draw on.

In short, the educational and science policies of the Cultural Revolution decade, of which mass science was an integral part, were on balance damaging to China's science and technology and national development, not because mass science in its simple form was not needed or could not work in China, but because it was distorted and abused for ideological and political reasons by the Gang of Four and their overzealous supporters. This type of political abuse of science and technology is perhaps one of the greatest dangers that can exist in an authoritarian and highly politicized society.

Since the downfall of the Gang of Four in 1976, important shifts in government policies have taken place. Modern science and technology are being stressed while mass science is seldom mentioned any more in the official publications. This has prompted many western observers to say that the new pragmatic and "modern-minded" leadership has reversed China's course of development and is pursuing a new science policy in which there is no place for mass science.

Predictions concerning China's future are always hazardous. *Assuming* that the new leadership is pragmatic and is willing to pursue a science policy that is appropriate to China's objective conditions, I feel that mass science in its functional form still has a useful role to play in China's future.

"Vehicle of Happiness," a mobile electric chair developed by a worker in cotton textile factory. Characters over picture of the worker-innovator say "The Province's advanced labor hero."

In my opinion, there are two important objective factors which the leaders should take into account in designing an "appropriate" science policy for the country. First and foremost is the stage of development of the country, including the development of its natural and human resources, etc. The second factor is the cost of acquiring more modern science and high technology in terms of the economic resources needed. For most developing countries, this depends to a large extent on the willingness of the industrialized countries to assist them, and on the terms, both economic and political, under which the assistance will be forthcoming.

Let us consider the implications of

Since this paper was written, Sino-American relations have dramatically improved with the U.S. recognition of China. China has also signed some large import agreements with Japan and some European countries. The fact remains, however, that China's ability to import technology from these industrialized countries will continue to be limited by her ability to export. This is also true with the amount of trade credit that foreigners are willing to extend to China. In addition, China's import priority is given to large industrial projects and military needs. Consequently, most industrial and agricultural production units still need to rely on their own initiative for technological improvements.—R.C.H.

these two factors for the appropriate science policy of a developing country. At a low stage of national development, resources are very limited and there are many competing claims on them; high-level scientific manpower is scarce and expensive to train. Under such circumstances, unless there exists a large amount of exportable natural resources such as petroleum, or unless foreign technology and economic resources are available at a low cost, both of which are highly unlikely, the country has no choice but to rely more on mass science to economize resources and get quick results in producing essential goods and services. This strategy is appropriate because basic human needs have to be satisfied first, and the country simply cannot afford too much high-level science that is not immediately related to production. In addition, the production structure of the economy is relatively simple and the degree of job specialization is relatively low at this stage of development, so that not much sophisticated science and technology are needed.

As the country reaches a higher level of development, the appropriate science policy will call for more higher education and modern science, with mass science playing a supplementary, not a dominant, role. The reasons are as follows. First, with a higher stage of development, basic human needs are presumably satisfied. Hence, the country can afford to spend a higher percentage of its national product on higher education and advanced research and development. Second, the production structure is more complex and specialized and entails more sophisticated technology, thereby requiring more professional expertise. Third, the country can better afford the importation of foreign technology because its capability to export manufactured goods has probably increased. Fourth, without more modern science and technology, further advances in mass science will become increasingly difficult.

If the above analysis is correct, then mass science is appropriate to the conditions of contemporary China. In the Cultural Revolution decade (1966-1975), China's stage of development was low compared with the industrialized countries. Relative to its enormous population, China's natural resources and high-level manpower were very limited. Further, due to ideological reasons, both the Soviet Union and the United States were hostile; hence, technology and resources from these two superpowers were unavailable. China's exports and thus its ability to import from other industrial countries were also limited. Under such circumstances, it was appropriate to stress mass science as the way to self-reliance in technology while cultivating professional science on a smaller scale. As I have argued earlier, where the radicals erred was not in advocating mass science as such, but in politicizing and distorting it at the expense of professional science, and in emaciating the pitifully small scientific community for ideological and political reasons.

These excesses are recognized by the new leadership and much-needed measures have been taken to correct them. However, the objective conditions of China have not changed that much since the mid-1970s. China remains an over-populated developing country, with agricultural growth only slightly ahead of population growth. Although production of oil has increased to enable exportation of some of it for foreign technology, domestic needs will grow to limit the extent of that export. Relations with the United States have not significantly improved. Foreign high technology remains expensive and China's import of foreign technology remains small relative to its needs.

China's future development and new science policy will be conditioned by these factors more than by the new ideology of "four modernizations." In spite of the new urgent stress on modern science and technology, advances will be slow and uneven, and the resources available for them will remain limited for a long time to come. The number of trained scientists and technicians will also remain small relative to the size of the population and to the needs of the society.[4] Therefore, the bulk of the basic production units in agriculture and industry will have no choice but to rely on the ingenuity of the peasants and workers for modest innovations and improvements or face technological standstill. These are the realities which Chinese scientists, at least those I talked to, fully recognize, and I believe that the new leadership is pragmatic and realistic enough to recognize them as well and to act accordingly. It is for these reasons that I expect mass science to play a useful, though not a dominant and glorified, role in the future; not to supplant professional science but to supplement it and perhaps even to induce its growth.

At the same time, because of their participation in production during the Cultural Revolution decade, the professional scientists of China, even in their new-found status, are not likely to be completely divorced from the needs of production in their research and development, as is often the case in India and many other developing countries. In this way, useful elements of the mass science policy of the discredited Gang of Four will ironically survive the political change to influence the future direction of China's development. □

1. The incomes of the collectives, after some deductions are made, are distributed to the members on the basis of their total work points accumulated during the year. Work points are awarded according to labor productivity.

2. For more detailed discussion of this concept of the malleability of ability and skills due to changes in individuals' thought, see Donald J. Munro, "The Malleability of Man in Chinese Marxism," *China Quarterly*, 48 (Oct./Dec. 1971), 634-35.

3. This is also the opinion of the scientists I talked to in China.

4. China's current goal is to reach 800,000 in scientific manpower in 1985.

As a presidential candidate, Mr. Carter pledged to reduce U.S. involvement in the conventional arms trade. His Administration, however, is not behaving much differently than its predecessors.

NICOLE BALL AND MILTON LEITENBERG

The foreign arms sales of the Carter administration

Both in his campaign for the presidency and in the weeks immediately after being elected, President Carter repeated that his Administration would have four primary goals in the area of arms control. These were:

- the reduction of nuclear weapon totals in a SALT agreement;
- the control of nuclear proliferation through supplier-nation limitations;
- the reduction of U.S. conventional arms transfers; and,
- the reduction of the U.S. defense budget.

Two years of his Administration have now passed and some qualified success in the first two goals has been achieved. However, the third—the effort to control and reduce conventional arms transfer—has been nearly a total failure. This article will discuss the political constraints that brought about this situation.

U.S. Senate approval of the controversial package sale of some 200 warplanes to Saudi Arabia, Egypt and Israel last May followed a long and heated debate which focused on the sale of military aircraft to Arab countries—Saudi Arabia in particular. Considering that when Mr. Carter took office some two years ago he promised to cut U.S. arms sales abroad, it is somewhat surprising that very little of the domestic criticism dealt with the question of whether *any* of these planes should be sold. Politics clearly held sway; the vote was seen by many as a test of U.S.-Israeli "special relationship."

While this points up the difficulty that exists in focusing on the issue of foreign arms sales per se, it is clear that the Carter administration is not behaving much differently from its predecessors on this issue.

Between 1950 and 1976, the United States transferred more than $110 billion worth of weapons and military-related services abroad. The two main channels through which these transfers were made are: a grant basis, using the Military Assistance Program; and a cash basis, under the Foreign Military Sales category. Until very recently, Military Assistance Program grants accounted for the bulk of these transfers. Foreign Military Sales are currently the largest conduit for U.S. military transfers [1-2]. Since 1972, a sizable amount of Foreign Military Sales has gone to developing countries, particularly Saudi Arabia and Iran [3].

The significant changes in the volume and the pattern of U.S. foreign military sales definitely began in the Nixon and Ford administrations and reflected the routine use of arms sales and transfers as the *quid pro quo* in diplomacy favored by then-Secretary of State Henry Kissinger. Political and diplomatic requirements came to outweigh strategic and security considerations in U.S. arms transfer policy. Some of these transactions were in fact concluded by the Secretary of State against the advice of the Joint Chiefs of Staff and the Department of Defense. The question, however, is whether the practice of using arms transfers as a regular diplomatic and political tool is not becoming institutionalized, despite Mr. Carter's pledges to reduce American involvement in the conventional arms trade.

Our purpose here is to look at:

- some of the most frequently advanced rationales for arms sales;
- the policy of restraint proposed by Mr. Carter in May 1977 and other legal restrictions on the sale of weapons;
- the actual U.S. arms sale situation since May 1977; and
- the resulting apparent early demise of possibilities for genuine reductions in the arms trade.

According to the Department of Defense, the primary purpose of arms sales is "to further the foreign policy objectives and serve the best interests of the United States" through the maintenance of regional military balances and by fostering "stability" in areas where military instability prevails [4]. However, the reality is frequently different:

- The United States has in several instances been the supplier of arms to neighboring nations that consider each other potentially hostile (Iran and Saudi Arabia).
- U.S. military supplies to Iraq under the Baghdad Pact (and not the issue of Israel) were the prime determinant of Nasser's initial acquisition of arms from the Soviet Union and Czechoslovakia. This provided the Soviet Union with an entrée into the Middle East and the middle eastern conflict.
- A military coup in a recipient country may overnight become a "destabilizing" factor to neighbors which had not felt threatened by the previous regime (Iraq, Ethiopia, for example).
- The very definition of military stability in a country with more than one neighbor that it considers potentially hostile (Peru and Bolivia-Chile or Iraq and Syria-Iran), and thus with planning requirements for arms supplies sufficient to overcome *all* potential opponents, ensures that arms supplies to the region will begin an upward ratchet mechanism, destroying any possible stability.

In addition, it is precisely those developing countries that are hostile to their neighbors—aside from those wanting arms for domestic political purposes or for "show"—that will be

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the most interested in purchasing arms when they can afford them, and often when they cannot [5].

The study known as "NSC 202"—prepared by the State Department to provide the "basic analysis" for the Carter arms sale restraint policy—offered a number of "arms transfer policy objectives," all centering around the notion that supplier nations can exert significant influence over recipients [6]. It can be argued, however, that arms transfers are but one of many transactions determining one country's hegemony over another, and that it is difficult to isolate their influence from the others. Most leverage seems to result from sole-supplier situations; but here, supplier nations must take into account the risks of armed conflict [7].

It is the Soviet Union which has suffered the most spectacular reversals of influence despite massive arms transfers: in Egypt, in Somalia, in Indonesia, and even in China. Since the United States has had many more arms clients than the Soviet Union, the deterioration of a relationship between the United States and one recipient nation is not seen to be as much of a decline in *overall* U.S. influence as when a U.S.S.R. client rejects the Soviet Union. Nevertheless, in at least two cases—Ethiopia and Brazil—political relationships have been altered drastically between the United States and major arms clients. The United States has also been experiencing difficulty with other client countries, namely Greece, Turkey and the Philippines.

The entire issue of human rights and arms transfers offers evidence that being a country's major arms supplier does not ensure that the supplier's views on human rights will be accepted by the recipient, or that the latter's attitude will change with the threat of cutting off supplies [6, p. 26]. In short, the relationship between arms supplier and recipient is complex. The power to influence actions is not limited to the supplier; recipients—particularly, but not exclusively, the wealthy, resource-endowed ones such as Iran and Saudi Arabia—can exert considerable influence over supplier-nations.

As a presidential candidate, Mr. Carter expressed these sorts of concerns: arms transfers can bring instability; weapons sales are inappropriate means through which to conduct a country's foreign policy. Presumably they contributed to the shaping of his arms sale restraint policy, which essentially rests on six major restraints and is hedged by three major exemptions:

- The first exemption is that none of the restraints apply to U.S. partners in major defense alliances: the 14 NATO countries, plus Japan, Australia and New Zealand. In addition, the United States is pledged to "honor our historic responsibilities to assure the security of the State of Israel." To date, only two Israeli requests have been turned down: for Pershing missiles and for fuel air explosive bombs.
- The second is the President's right to waive any of the restraints under "extraordinary circumstances."
- Finally, Mr. Carter has emphasized that multilateral supplier-nation cooperation must be exercised —as in the case of the London Nuclear Suppliers' Club—if the global trade in arms is really to be reduced. [8]. In the recent past, neither the Soviet Union, the United Kingdom, nor France—countries which, along with the United States, account for close to 90 percent of the international trade in arms—have shown themselves to be interested in limiting their exports of weapons. France's President Giscard d'Estaing stated publicly that France would not consider any controls on its own arms exports without Soviet participation. U.S.-USSR negotiations on Conventional Arms Transfer were announced in May 1978. After several preliminary discussions in the intervening months, an announcement in late October 1978 stated that the United States and the Soviet Union would begin "concrete negotiations" aimed at creating common guidelines on the supply of conventional weapons to Africa and to Latin America. The negotiations began in December in Mexico City.* The Soviet Union is reportedly interested in the definition of a "code of principles" that would govern arms transfer. Apparently, one concrete suggestion by the Soviets was that each country refrain from selling weapons to any nation on the other's borders. This was an obvious attempt to forestall western arms sales to China. A second suggestion was that the principles ban the supply of arms to nations that refuse to agree to arms control pacts. This too was clearly aimed at China.

The negotiations are structured around defining a framework for potential controls. The framework is to be built around political and legal rules, military and technical criteria, and regional agreements. It will be a distinct challenge for these talks to lead to more significant progress than past negotiations on other highly political arms control issues, such as SALT or mutual and balanced force reductions (MBFR). If the talks do not produce significant results with the Soviet Union, and if France and Britain were to refuse to join in, it can be expected from the tone of President Carter's statement of November 29, 1978 that unilateral U.S. restraints of any sort are not likely to last much longer. In that case, the President may yet invoke the failure of multilateral cooperation as a means of voiding U.S. restraints on any particular sale or, perhaps, on the entire policy.

There are six restraints:

- The first restraint proposed by

* These negotiations resulted in a debacle, largely due to the actions of National Security Council Director Zbignew Brzezinski. It is clear that political power considerations will continue to overwhelm any general arms control efforts by the Administration. It is ironic that Mr. Carter's own National Security Adviser was instrumental in making such short shrift of a basic concern of the President's arms control policy. The U.S.-USSR negotiations are the only framework in which one can expect to impose restraints on Soviet conventional arms transfer policy; and other international controls are dependent on U.S.-USSR restraint agreements.

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Mr. Carter is that a dollar ceiling be placed on U.S. arms exports and that it be lowered annually. The ceiling has come to be seen as the "cornerstone" of the Carter arms-restraint policy, but in fact it has had no impact on overall U.S. sales. Sales and transfers to the 17 "exempt" countries are excluded from it. In fiscal 1977, these countries accounted for some $1.2 billion of the $11.5 billion in U.S. arms transfers and their purchases rose to $2.2 billion in fiscal 1978 [9].

In addition, certain weapons (notably those sold commercially by American companies) and some weapons-related services (training, construction, administration, technical assistance) are also excluded. [2, p. 4]. According to Arms Control and Disarmament Agency figures, construction, training and administration accounted for 34 percent of U.S. arms trade in fiscal 1976 [10].

Finally, according to a recent General Accounting Office study, the Carter administration used inflated 1977 figures to determine the 1978 arms export "ceiling." Thus, while the Administration claims that the 1978 "ceiling" of $8.55 billion is nearly $700 million less than the 1977 "ceiling," the General Accounting Office reports that the actual reduction is one on the order of $66 million [11].

• The second restraint is that the United States will not be the first to introduce the most sophisticated form of a weapon into a region. But the policy does allow weapons transfers where "countries friendly to the United States must depend on advanced weaponry to offset quantitative and other disadvantages in order to maintain a regional balance" [8, p. 12]. Such a category would seem to offer another substantial loophole in the restraint policy.

• The third restraint is that the development of advanced weapons solely for export would not be allowed. Since very few weapons have so far been produced "for export only" this restriction will have little immediate impact on arms sales levels [2, p. 5], but a trend toward production of "export only" weapons seems to be developing and the future importance of this restraint should not be underrated.

• Fourth, controls are to be placed on the co-production of American weapons under license in foreign countries. About three-quarters of all current co-production agreements, however, are in the 17 exempt countries. Nor are commercial licensing agreements made with U.S. arms producers included here [2, pp. 5-6; 3, p. 6].

• Fifth, contractual restraints may be placed on the transfer of weapons from the original foreign purchaser to a third country when the weapon is sold. But the degree of effective control that can be maintained once a weapon leaves the United States is dubious. [12].

• There is also considerable doubt about adequate enforcement of the sixth restraint. This concerns controls on U.S. weapons firms seeking to sell abroad, and on the cooperative relationship which frequently develops between American corporate representatives and U.S. embassy and military personnel abroad [2-3; 8, pp. 19-25].

Thus, it is apparent that considerable scope exists for circumventing the Carter arms restraint policy. The Administration's failures to comply with its own restrictions are growing in number.

There are at least two other areas in which arms transfer restraints should, by law, be applied but where the Administration has thus far shown itself to be less than enthusiastic in doing so.

• Congress has passed legislation requiring the cessation of military sales, loans and grants to countries in which there is a "consistent pattern of gross violations of internationally recognized human rights." The State Department study, "NSC 202," presented a number of reasons [6, pp. 26-27] why the government should not apply such restrictions across the board. These revolved around loss of influence over such countries and their "collective importance" in terms of U.S. security interests. And despite cutbacks in military assistance to Brazil, Uruguay and Nicaragua on human rights grounds, the Administration continues to supply them with "domestic repression" instruments: "nonmilitary" aircraft, trucks, shotguns, rifles, shackles, leg-irons, thumbscrews and the like [13]. (It also supplies these items to other human rights offenders such as South Korea, Iran, Chile, the Philippines, Indonesia, the Dominican Republic, and Saudi Arabia—all of which are still able to obtain a full supply of U.S. military equipment.)

• The Arms Export Control Act of 1976 states in Section 35 that the President can terminate arms sales and guarantees to any developing country which diverts development assistance or its own resources to "unnecessary military expenditures" [14]. Each year, the U.S. Agency for International Development (USAID) prepares a report from the President to the Congress on "the quantity and nature of military expenditures" by countries receiving various types of American Assistance [15]. In 1976, some 24 countries were identified as having exceeded "comparative norms" computed by USAID on the basis of percentage of gross national product devoted to military expenditure, the level of military imports and budgetary expenditure. In each instance, it was concluded that the "economic resources intended for economic development were *not* diverted to military purposes" (emphasis added) [15, p. 2].

Had the President wanted to curtail arms sales to any of these 24 countries, it seems likely that the information on which the USAID report was based could have demonstrated that any one of them was "diverting its own resources to unnecessary military expenditure." By adopting the rationales in the report, the Carter administration gave yet another indication that its concern to reduce the global trade in arms is not very strong.

In the first four months following the announcement of the policy of

The industrialized countries have no intention of reducing their own production and consumption of weaponry. And Third World countries are in no way forced to buy arms; they actively seek them.

restraint, the Administration sent 45 arms sale notifications to Congress in transactions involving 18 countries and totalling $4.1 billion. Of these, 27 transactions (totalling $3.3 billion) were for less developed countries. Iran alone accounted for ten (totalling $2.2 billion), including the controversial sale of seven E-3A Airborne Warning and Control Systems. This sale, if consummated, would certainly violate Carter's "restraint" of not being the first to introduce sophisticated weaponry into an area.

Also in this period, "agreements in principle" for the transfer or sale of U.S. military equipment were reported with Somalia, Sudan, Chad, Saudi Arabia and South Korea [8, pp. 26-31]. Somalia's expanded activity in the Ogaden at the end of 1977 temporarily halted further discussions; by June 1978, the Administration was prepared to send a military mission to Somalia to discuss the transfer of $15 million in "defensive" arms [16]. The Saudi agreement in principle was incorporated into the recently approved Mideast package deal.

In the same four months, the refusal of only three arms deals was announced. Israel lost its appeal for the right to sell Kfir fighters, fitted with American engines, to Ecuador. A Pakistani request for A-7 fighter-bombers was turned down, as was the Iranian purchase of F-18Ls [8, pp. 31-32]. It has been suggested that the third "restraint"—no development of "export only" advanced weaponry—was aimed at the proposed F-18L deal [17]. In turning down the A-7 request, the Administration cited the desire not to upset the military balance in South Asia. Unfortunately, *both* India and Pakistan have subsequently been offered less sophisticated weaponry.

The Administration has argued, of course, that many of these transactions were "inherited" from the Nixon-Ford years. Some critics have suggested that this was more an excuse than an argument, while others were willing to "wait and see." But the situation seems to be developing badly. In 1977 the Department of Defense had estimated total arms transfers for fiscal 1978 would amount to $13.2 billion. Just before the end of the year, the Administration claimed that the original $13.2 figure would not be exceeded [18]. In fact, figures released on October 1, 1978 showed a total of $13.7 billion in arms and arms-related transfers.

The Administration claimed that the 1978 "ceiling" of $8.55 billion—which in any case the GAO demonstrates should not have exceeded $8.0 billion—had been maintained [9]. But this was accomplished by deferring the final transactions on several orders until fiscal 1979 and 1980 [19]. It is also possible that the $1 billion in sales to some countries (Guatemala, Mexico, Taiwan and Pakistan), which Undersecretary of State Lucy Benson cited as having been rejected will surface once again in future years [18].

Just over one year after unveiling a policy designed to curb the "spiralling arms traffic" the Carter administration succeeded in getting Congress to lift the ban on arms sales to Turkey, where Turkish forces used American equipment while invading Cyprus in 1974* and the United States was seeking a lever to bring Turkey to the negotiating table with Greece. Mr. Carter and some members of the Congress held that the arms embargo was having the opposite effect: Turkey refused to negotiate "under duress."

More important, however, have been two political considerations. The first centered around fears of the weakening of NATO's southeastern flank and indications of Turkish diplomatic initiatives toward Warsaw Pact nations. The settling of the Cyprus conflict would clearly be the greatest factor in repairing NATO ties and the Administration assumes that arms supplies are the means to that end. The second concern was the Turkish threat of permanent closure for U.S. military bases temporarily closed in 1975 to protest the arms embargo. After the ban was lifted, however, it was revealed that only five bases had been shut down, not 26 as originally reported. Of these five, four which are strategically important USSR-listening posts were to be opened as soon as possible [20].

There are several other proposed arms sales which suggest that the Carter administration is using foreign military sales as a diplomatic and political tool on a regular basis [8, p. 1].

While visiting Indonesia in May 1978, Vice President Mondale reportedly told Jakarta that if "human rights" were improved Indonesia would be allowed to buy the squadron A-4s it had been seeking [21]. Indonesia has from 50,000 to 100,000 political prisoners and it was the U.S. State Department's position that at least some of these should be released before the A-4 deal could proceed.

The "human rights" issue aside, the A-4 deal has some curious aspects. Each plane is being sold at a fraction of cost. Furthermore, the 28 planes sold will be reconditioned to produce 14 to 16 operational aircraft. The work will be done by private DOD contractors and the cost will not be included in the sale price. This bookkeeping trick will keep the recorded price below $7 million, so that Congressional approval is not required, as it is for sales in excess of $7 million [22].

Discussing the sale of a squadron of F-5Es to Thailand, Mr. Mondale is quoted as stating that "These deals are not headline items at home. But they are important symbols to these countries of our support" [21]. One could easily think of other "symbols" that the American government might offer and which might actually benefit these countries economically and socially. Such alternatives, however, do not seem as attractive to government leaders, either in donor or

* It is interesting to note that when Israel violated the terms of transfer of U.S. cluster bomb munitions by using them in Lebanon earlier in 1978, Administration officials and Senate members stated that they "preferred not to think about the violation." The Administration was, of course, in the midst of pushing its Mideast plane package through the Congress.

Despite the Administration's stated policy, there is little chance of a sharp drop in U.S. sales. And without such a drop, there is almost no chance for reductions by the other major arms suppliers.

recipient countries, as squadrons of warplanes, radar systems, frigates, missiles and the like.

Third World opposition has been at least partly responsible for the failure of attempts to deal with the conventional arms transfer issue in the U.N. General Assembly. At the same time, many developing countries claim that a policy of restricting the international arms trade looks to *them* as if the industrialized seller nations were attempting to maintain the military predominance of rich countries. Indeed, much of the material generated prior to the U.N. Special Session on Disarmament has emphasized the need to reduce Third World arms purchases [23].

In fact, neither the major arms suppliers nor Third World recipients are eager to see arms sales restraints imposed. The industrialized countries have no intention of reducing their own production and consumption of weaponry. Third World countries are in no way forced to buy arms; they actively seek them. It is conceivable that they would attempt to oppose constraints under any conditions, even if the industrialized nations limited *their own* conventional arms acquisitions.

The U.N. Special Session evoked a number of suggestions for dealing with the conventional arms race. An Aspen Institute paper called for a ceiling to be set on the percentage of gross national product (GNP) devoted to every form of military expenditure by all countries [24]. But developing countries might argue that, because the United States and the Soviet Union have such large GNPs, this system inherently accepts the continued predominance of the major powers. At the same time, it must be recognized that a seemingly low percentage of GNP devoted to military expenditure can mask a substantial diversion of budgetary resources to military purposes (See table).

It seems clear that despite the Carter administration's stated policy, there is little chance of a sharp drop in U.S. sales. And without such a drop, there is almost no chance for reductions by the other major world arms suppliers.

An early and highly important decision taken by the Administration was to accept the entire $27 billion backlog of Foreign Military Sales orders negotiated during the Nixon and Ford years. By the beginning of fiscal 1979, there was a $43.5 billion backlog of deliveries stretching to 1986 [25]. Thus, while the Carter administration may refuse an arms sale here or there, the number of U.S. weapons actually delivered will not decline during Carter's present term of office, nor is it likely to do so if he were re-elected in 1982. Furthermore, it has been hinted that the oil-exporting Mideast countries and South Korea might join the list of

Comparison of Military Expenditure in Selected Less-Developed Countries as Percent of National Budget and of Gross National Product

Country	*Military Expenditure*	
	National Budget[a] *(Percent)*	*GNP*[b] *(Percent)*
Yemen, Democratic	57.8	10.50
China, Republic of (Taiwan)	42.8	7.03
Pakistan	33.5	5.68
Yemen	47.6	5.26
Malaysia	17.1	4.85
Korea, South	29.7	4.53
Lybia	10.9	3.51
Zambia	13.3	3.31
Sudan	17.7	3.18
Tanzania	11.0	3.15
India	25.3	3.03
Morocco	10.0	2.74
Mali	17.7	2.48
Ethiopia	18.0	2.33
Central African Empire	9.0	2.30
Algeria	7.3	2.28
Bolivia	15.7	2.24
Brazil	25.4	2.05
Venezuela	5.5	1.99
Togo	13.7	1.83
Afghanistan	14.8	1.61
Haiti	27.0	1.31
Paraguay	14.7	1.27
El Salvador	9.6	1.25
Jamaica	3.3	0.64

[a]Data derived from Leitenberg and Ball, "The Military Expenditure of Less Developed Nations as a Proportion of their State Budgets. A Research Note," *Bulletin of Peace Proposals* 8:4 (1977), 312–314.

[b]U.S. Arms Control and Disarmament Agency, *World Military Expenditures and Arms Transfers*, 1966-1975 (Washington, D.C.: 1976), Table II, pp. 19-54.

"exempt" countries when future arms sale "ceilings" are computed [26].

The announcement of the $8.4 billion fiscal 1979 "ceiling" did not list any new exemptions. But the President did indicate, in announcing the new "ceiling," that future "ceilings" on U.S. arms sales to nonallied Third World countries will depend on cooperation by other major supplier-nations [27]. U.S. arms producers are pushing for an end to the restraint policy, pointing out that other arms suppliers are only too eager to take advantage of the few cases in which the U.S. does refuse to make a sale [25, 28]. The prospects for a "London Group" type arrangement for conventional arms sales control are not promising. Few expect such an outcome. Once the United States drops its attempts at reducing its own foreign arms sales, *it will be impossible for the Administration to push other arms producers to reduce their sales.* At the same time, the Administration appears unable to continue its own minimal controls without participation by the other major supplier-nations, particularly the Soviet Union.

Thus, without some rapid and significant results from the U.S.-USSR negotiations, it is very unlikely that any significant change in world arms trade will occur as a result of the arms sales restraint policy enunciated by President Carter in May 1977. On the other hand, should the conventional arms transfer negotiations produce results, it will be a very strong indication that a prior unilateral policy change by the United States set the conditions for multilateral controls.

According to press reports in late December 1978 the situation in Iran prompted the Joint Chiefs of Staff to suggest that particular advanced military hardware sold to Iran in recent years be dismantled, destroyed or removed if the crisis worsens. Clearly, another criterion for arms transfers should be—should always have been —that no piece of military equipment should ever be sold to a nation if the donor nation feels that it would be necessary to retrieve or to destroy it under a change of government in the recipient nation. Ironically, the same press reports told of increased U.S. arms transfers to Pakistan, Turkey and various Arab nations, and possibly even the development of a new "special relationship" with India of the sort that the U.S. has had with Iran since 1970.

1. U.S. Department of State, Bureau of Public Affairs, "U.S. Conventional Arms Transfer Policy," GIST, Nov. 1977.

2. Center for Defense Information, "U.S. Weapons Exports: Can We Cut the Arms Connection?" *The Defense Monitor* 7 (Feb. 1978), p. 6.

3. Michael T. Klare and Max Holland, *Conventional Arms Restraint: An Unfulfilled Promise,* Issue Paper (Washington, D.C.: Institute for Policy Studies, 1977), p. 3.

4. David Binder, "Comprehensive U.S. Arms Sale Policy Seen as Means of Restraining Other Suppliers," New York Times, March 8, 1978), 6.

5. Edward C. Luck, "Does the U.S. Have a Conventional Arms Sale Policy?" *Arms Control Today* 6 (May 1976), 1, 2, 4.

6. U.S. Congress, Senate, Committee on Foreign Relations, Report: *Arms Transfer Policy,* 95th Cong., 1st Sess. (Washington, D.C.: U.S. Govt. Printing Office, July 1977), pp. 11-12 (hereafter referred to as "NSC 202"). This is the unclassified version of the report.

7. Stockholm International Peace Research Institute, *The Arms Trade with the Third World.* (Stockholm: Almqvist & Wiksell, 1971), p. 73.

8. For an elaboration of the multilateral restraints envisaged by Carter, see Herbert Y. Schandler, Robert G. Bell, Richard F. Grimmett and Robert D. Shuey, *Implications of President Carter's Conventional Arms Transfer Policy,* 77-223 F (Washington, D.C.: Congressional Research Service, Library of Congress, Sept. 22, 1977), p. iii.

9. Charles W. Corddry, "U.S. World Arms Sales Judged at $13.7 Billion," Baltimore Sun, October 1, 1978.

10. "Why Carter Will Have a Tough Time Trying to Curb Arms Sales," *U.S. News & World Report,* Aug. 1, 1977, p. 39.

11. U.S. General Accounting Office, *Arms Sales Ceiling Based on Inconsistent and Erroneous Data,* FGMSD-78-30 (Washington, D.C.: April 12, 1978).

12. Don Oberdorfer, "Exports of U.S. Arms Pose Thorny Question of Control," Washington Post, May 14, 1978, p. 17.

13. Cynthia J. Arnson, "The Exporting of Torture by America," Los Angeles Times, April 26, 1978.

14. U.S. Public Law 90-629, Arms Export Control Act, Section 35(a), "Foreign Military Sales to Less Developed Countries."

15. U.S. Agency for International Development, "Annual Report of Implementation of Section 620(s) of the Foreign Assistance Act of 1961, As Amended," April 1977, p. 1.

16. Don Oberdorfer, "U.S. Revives Plan to Sell Defensive Arms to Somalia," Washington Post, June 2, 1978, p. A1; "Aid Mission in Somalia to Continue," Baltimore Sun, June 8, 1978, p. 4.

17. Cecil Brownlow, "Arms Exports Curbs Expected to Bend," *Aviation Week & Space Technology* 106 (June 6, 1977): 85, 87.

18. "Arms Sales Reduced, Administration Says," *Ithaca Journal,* Aug. 23, 1978.

19. See "Washington Roundup: Sale Limit Squeeze," *Aviation Week — Space Technology* 109 (Sept. 18, 1978), 13.

20. On the lifting of the arms ban on Turkey, see, for example, Dusko Doder, "Turkey to Permit 4 Key American Installations to Reopen," Washington Post, Oct. 10, 1978, pp. A1, A18; Sam Cohen, "U.S. Bases in Turkey to Reopen," Christian Science Monitor, Oct. 6, 1978, p. 7.

21. Terence Smith, "Mondale is a Nonexpert who Matters," New York Times, May 14, 1978, Sec. 4, p. 1.

22. Emergency Committee for Human Rights in Indonesia and Self-Determination in East Timor, "V. P. Mondale's Promise to Sell 28 A-4C Bombers to Indonesia" (Ithaca, N.Y.: 1978), p. 1.

23. Jane Sharp, "Isaiah Revisted," *The Bulletin of the Atomic Scientists* 34 (May 1978); U.S. Department of State, Bureau of Public Affairs, "U.N. Special Session on Disarmament," GIST, April 1978.

24. Lincoln P. Bloomfield and Harlan Cleveland, *Disarmament and the U.N.: Strategy for the United States,* A Policy Paper (Princeton, N.J.: Program in International Affairs, Aspen Institute for Humanistic Studies, 1978), pp. 29-35.

25. George C. Wilson, "Carter's Arms Sales Policy is Assailed," Washington Post, Oct. 6, 1978, p. A2.

26. "Rise in Total U.S. Arms Sales Seen Despite Curbs Set for FY 1978," New York Times, Feb. 2, 1978; Charles W. Corddry, "Pentagon Says Arms Sales Could Rise to $13.2 Billion," Baltimore Sun, Jan. 17, 1978, p. 1.

27. Don Oberdorfer and Edward Walsh, "Carter States New Goals for Reducing Arms Sales," Washington Post, Nov. 30, 1978, pp. 1, 3.

28. "Carter Cuts Back Exports of Arms to Countries Not Allied with U.S.," New York Times, Nov. 30, 1978, pp. A1, A3.

A longer version of this article will appear in *Alternatives, a Journal of World Policy* this spring.

Leo Szilard: His version of the facts

In this issue, the *Bulletin* begins the publication of excerpts from a new book, *Leo Szilard: His Version of the Facts,* edited by Spencer R. Weart and Gertrud Weiss Szilard.

To many of our readers, Leo Szilard is well known as one of the *Bulletin*'s founding sponsors and a regular contributor from 1946 until his death in 1964.

Leo Szilard was a scientist who, not content to remain in the laboratory, went beyond its walls to attend to the larger causes of humanity. External crises several times interrupted his scientific career, as would be expected for anyone of central European ancestry born in Budapest in 1898. But even after he came to the relative security of the United States in 1938, his career was often interrupted, by his own will: he pressed the Americans to make nuclear weapons before Nazi Germany did; he was then among the first to fight against the actual use of the bombs he had done much to create; he switched from nuclear physics to biology in order to keep abreast of the moving edge where scientific discovery vitally affects mankind. Until his sudden death in California in 1964 he threw himself time and again into schemes to advance world peace. Beneath all this turbulent movement he held confidently and with absolute consistency to his single goal—creating what he called "a more livable world."

At various times Szilard considered writing his autobiography, but his interest was always captured by the present and the future. Therefore he was not inclined to spend much time on the past and never wrote more than fragments. He had a sense of history, however, and carefully preserved correspondence and other documents which he considered historically significant. In 1951, he contemplated writing a history of the Manhattan Project and organized pertinent documents and drafted some notes, among which we found the following anecdote.

While talking to a colleague about some disturbing things that had happened during the project, Szilard said that he was going to write down the facts, not for publication, just for the information of God. When his colleague remarked that God might know the facts, Szilard replied that this might be so, but "not *this* version of the facts."

The recently published book excerpted here through the courtesy of Mrs. Szilard and the MIT Press presents Szilard's version of the facts through the tape-recorded interviews, supplemented by correspondence and other documents. Most of the tapes were recorded in 1960 during a period of serious illness which kept him in the hospital for a year. At that time a tape recorder was put into his room supposedly for the purpose of recording his memoirs. Being interested more in the future than in the past, he used it chiefly to dictate the first draft of the utopian story *The Voice of the Dolphins and Other Stories* (Simon and Schuster, 1961). However, on a few occasions he responded with zest to questions about his past, and then the tape recorder was switched on. Other reminiscences were recorded in 1956 and 1963. The tapes found in the Szilard files, many transcribed posthumously, deal with the period from his childhood to the year 1946 only. The editors tried to use only a minimum of scholarly apparatus and let Szilard himself speak.

A previous volume, containing his scientific papers, was published several years ago, and a draft manuscript, "Beyond Science Toward a Livable World," has been prepared which contains Szilard's social and political writings after 1946.

—The Editors

The young Szilard

Student days in Budapest, 1915. (right) Portrait at time of enrollment at the Institute of Technology in Budapest, Hungary, 1916.

As far as I can see, I was born a scientist. I believe that many children are born with an inquisitive mind, the mind of a scientist, and I assume that I became a scientist because in some ways I remained a child.

Very often it is difficult to know where one's set of values comes from, but I have no difficulty in tracing mine to the children's tales which my mother used to tell me. My addiction to the truth is traceable to these tales and so is my predilection for "Saving the World."

Apart from my mother's tales the most serious influence on my life came from a book which I read when I was ten years old. It was a Hungarian classic, taught in the schools, *The Tragedy of Man*. I read it much too prematurely and it had a great influence on me, perhaps just because I read it prematurely. Because I read it I grasped early in life that "it is not necessary to succeed in order to persevere."

I was the oldest of three children, and we lived in a house which belonged . . . originally to my grandparents. Then it was inherited by three sisters, of whom my mother was one, and each sister had a whole floor. It was a house with a large garden in the cottage district of Budapest. . . . I remember that I was already very intensely interested in physics when I was thirteen. At that time I got a few playthings in physics, and I remember how overjoyed I was.

I must have made a rather strong impression on my schoolmates, judging from the fact that they reported to me years later conversations which they had had with me and which I had forgotten. One of these "memorable" conversations occurred at the outset of the First World War. I was sixteen at the time, and when the war started we didn't have a very good conception of what kind of an enterprise this was. Most people thought that the war would last just a few months and, as the German Kaiser once said, our troops would be back by Christmas. He meant Christmas, 1914.

There was speculation in the class as to who might win the war, and apparently I said to them at the time that I of course did not know who would win the war, but I did know how the war ought to end. It ought to end by the defeat of the central powers, that is the Austro-Hungarian monarchy and Germany, and also end by the defeat of Russia. I said I couldn't quite see how this could happen, since they were fighting on opposite sides, but I said that this was really what ought to happen. In retrospect I find it difficult to understand how at the age of sixteen, and without any direct knowledge of countries other than Hungary, I was able to make this statement. Somehow I felt that Germany and the Austro-Hungarian Empire were weaker political structures than both France and England. At the same time I felt that Russia was a weaker political structure than the German Empire.

I am inclined to think that my clarity of judgment reached its peak when I was sixteen, and that thereafter it did not increase any further and perhaps even declined. Of course, a man's clarity of judgment is never very good when he is involved, and as you grow older, and as you grow more involved, your clarity of judgment suffers. This is not a matter of intelligence; this is a matter of ability to keep free from emotional involvement.

The set of values of the society in which I lived in Budapest was conducive for a young man to dedicate himself to the pursuit of science, and the poor quality of the teaching of science at the universities in Hungary furnished stimulation to independence of thought and originality. [In 1916], one year before I was drafted, I entered the Hungarian Institute of Technology as a student in order to study electrical engineering. My real interest at that time was physics, but there was no career in physics in Hungary. If you studied physics, all that you could become was a high school teacher of physics—not a career that had any attraction for me. Therefore I considered seriously doing the next best thing and studying chemistry. I thought that if I studied chemistry I would learn something that was useful in physics and have enough time to pick up whatever

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physics I needed as I went along. This I believe in retrospect was a wise choice. But I didn't follow it, for all those whom I consulted impressed upon me the difficulty of making a living even in chemistry, and they urged me to study engineering. I succumbed to that advice, and I cannot say that I regret it, because whatever I learned while I was studying engineering stood me in good stead later after the discovery of the fission of uranium.

The war years were rather uneventful for me, even though one year before the end of the war I was drafted into the army. In Austria and Hungary, again corresponding to the set of values of those times in those localities, a young man who had high school education was automatically scheduled to become an officer, so I was sent to officers' school. And again in accordance with the set of values of those times, I ended up third in the officers' school of the brigade in spite of my rather unmilitary posture. Even though I was obviously not what you might call a good soldier, my teachers were impressed with my ability to grasp scientific and technical problems. Because I was able to explain how the telephone worked when nobody else in the class could explain the functioning of this mysterious gadget, I had a certain amount of standing in the class; and in spite of my unmilitary behavior I ended up third in my class, which comprised the officers-to-be of that particular year.

Since people have no imagination whatsoever, they cannot imagine in peacetime that there should be war, and if the war goes on for a few years, they cannot imagine that there ever will be peace. So, by the time of the third year of the war when I was drafted and sent to officers' school, nobody could imagine that war would ever end, and therefore more and more emphasis was put on the thorough training of officers.

The collapse of the Austro-Hungarian army was followed by a troubled period in Hungary that ended with the Communist government of Bela Kun, which lasted about four months [summer, 1919, at which time Szilard had returned to the Institute of Technology]. This government lasted too short a time to be able to do anything except hold office. During this period the things which had deteriorated during the war deteriorated even further, and I made up my mind that I wanted to leave Hungary to study in Germany.

I left Hungary [around Christmas, 1919] to go by way of Vienna to Berlin. This was about the worst time after the war because of the coal shortage. There was a shortage of food and there was a shortage of coal; because of the shortage of coal travel was slow, and as a matter of fact it took me two weeks to get from Budapest through Vienna to Berlin.

I applied for admission to the Technische Hochschule of Berlin. This permission I finally got, but not without difficulty and not without having to bring to bear all the pressure I could through such private connections as I was able to muster in the city of Berlin.

Berlin at that time lived in the heyday of physics. [Albert] Einstein was there, Max Planck and [Max] von Laue were at the University of Berlin, and so was Walter Nernst; and Fritz Haber was at that time director of the Kaiser Wilhelm Institutes. Engineering attracted me less and less, and physics attracted me more and more, and finally the attraction became so big that I was physically unable to listen to any of the lectures through which I sat, more or less impatiently, at the Institute of Technology.

Even though all arguments mustered by the conscious spoke in favor of getting a degree in engineering rather than getting a degree in physics, whatever considerations went on at the subconscious level argued for the opposite. In the end, as always, the subconscious proved stronger than the conscious and made it impossible for me to make any progress in my studies of engineering. Finally the ego gave in, and I left the Technische Hochschule to complete my studies at the University, some time around the middle of '21.

A student of physics had great freedom in those days in Berlin. Boys left high school when they were eighteen years old. They were admitted at the University without any examinations. There were no examinations to pass for four years, during which time the student could study whatever he was interested in. When he was ready to write a thesis, he either thought of a problem of his own or he asked his professor to propose a problem on which he could work. At the better universities, and Berlin belonged to them, a thesis in order to be acceptable had to be a piece of really original work. If the thesis showed the student to be really able and was accepted, the student had to pass an oral exam.

At some point, rather early, I went to von Laue, who was a professor of theoretical physics, and asked him whether he would give me a problem on which I could work to get my doctor's degree. . . . I had this problem [in the theory of relativity] which von Laue gave me, but I couldn't make any headway with it. As a matter of fact, I was not even convinced that this was a problem that could be solved. I forced myself to work on it, but it just wouldn't go at all. This went on for about six months. Then came Christmas 1921; and I thought

Christmastime is not a time to work, it is a time to loaf, so I thought I would just think whatever comes to my mind. Pretty soon things began to come into my mind in a field completely unrelated to the theory of relativity.

I went for long walks and I saw something in the middle of the walk; when I came home I wrote it down. There was an onrush of ideas, all more or less connected, which just kept on going until I had the whole theory fully developed. It was a very creative period, in a sense the most creative period in my life, where there was a sustained production of ideas. Within three weeks I had produced a manuscript of something which was really quite original. But I didn't dare take it to von Laue, because it was not what he asked me to do.

There was a seminar for students which Einstein held at the time, which I attended, and after one of these seminars I went to him and said that I would like to tell him about something I had been doing. He said, "Well, what have you been doing?" And I told him what I had done. And Einstein said, "That's impossible. This is something that cannot be done." And I said, "Well, yes but I did it." So he said, "How did you do it?" It didn't take him five or ten minutes to see, and he liked this very much. This then gave me courage and I took the manuscript to von Laue. I caught him as he was about to leave his class and I told him that while I had not written the paper which he wanted me to write, I had written something else, and I wondered whether he might be willing to read it and tell me whether this could be used perhaps as my dissertation for the Doctor's degree. He looked somewhat quizzically at me, but he took the manuscript. And next morning, early in the morning, the telephone rang. It was von Laue. He said, "Your manuscript has been accepted as your thesis for the Ph.D. degree."

Next month: Szilard and Einstein

DAVID DAVIES reviews

Nuclear Explosions and Earthquakes: The Parted Veil
by Bruce Bolt
W. H. Freeman, 1976
330 pages, $12.00

Monitoring Underground Nuclear Explosions
by Ola Dahlman and Hans Israelson
Elsevier, 1977
440 pages, $49.00

A comprehensive test ban (CTB) outlawing all nuclear weapons tests has been in and out of the news for the past 20 years. There have been periods of optimism, such as in 1958 when scientists first met in Geneva and outlined a possible monitoring system, or in 1963 during the negotiations which only yielded a treaty banning tests in the atmosphere, space and under the water. There have also been depressing periods when a comprehensive test ban looked out of the question. Much of the period between 1958 and 1963 was such a time, when politicians haggled fruitlessly over numbers of inspections, black boxes and big-hole decoupling. Another was the many years after 1963 in which the superpowers seemed not to have the political will to resume negotiations.

But at present the omens are good. The Soviet Union, United States and United Kingdom are apparently hard at work trying to hammer out a comprehensive test ban for general consumption. The Conference of the Committee on Disarmament, now 31 nations in number, is busying itself with its own technical discussions and is looking for something substantial from the three nuclear powers. According to the pundits, the chances are 50/50 that we will soon see a treaty. But the pundits have rated the chances 50/50 many times before.

There is every reason why a non-nuclear nation, particularly a signatory to the Non-Proliferation Treaty, should want a comprehensive test ban. But there are significantly fewer reasons why nuclear powers with vigorous weapons programs should be so keen. However, possible grounds for a comprehensive test ban could be:

- concern over the cost of a weapons testing program;
- belief that an end to weapons testing would place one's adversary at a disadvantage;
- conviction that there was political mileage, domestic or international, in being seen to want a comprehensive test ban;
- a reckoning that laboratory experiments and simulations could conveniently replace full-scale detonations;
- pressure from friendly nations affronted by continuous test activity; or even
- a genuine desire to stop weapon testing.

No doubt all of these and other reasons conspire at particular times to push the pace of negotiation along. But if discussions do indeed seem to be becoming productive, the public will probably be told that recent advances in seismic monitoring systems now make a comprehensive test ban possible. This is not really true; certainly there have been slow evolutionary changes in the past five or ten years, but none that would now make a ban possible where previously it was not.

Seismology was, as recently as 1958, a science hardly touched by modern developments. True, seismic prospecting had for many years been turning up hydrocarbon resources and had been developing into a fine art. But little of this had rubbed off on global seismology, which had been starved of resources, both intellectual and financial.

It was into this world that the politicians and the military came bursting with questions which had never been posed before: What were

the smallest detectable blasts? Could they be discriminated from earthquakes? How could the limiting background noise be reduced? Was there any sense in recording at very great distances? Were there ways of disguising explosions, or even suppressing their signals?

The amount of paper generated during the last 20 years in answering these questions has been enormous, as industrial contractors in the United States have vied with each other with volumes of data, manipulated to the last decibel. But overviews of the subject have been very few.

Ten years ago the Stockholm International Peace Research Institute (SIPRI) convened a conference at which Eastern, Western and neutral countries worked out an agreed statement to which I, as rapporteur, had to add a supporting technical text.

The SIPRI report (Seismic Methods for Monitoring Underground Explosions) has worn remarkably well as a basis for international discussion. Largely this is because it came at a time when most of the basic research had been done; in the past ten years most of the action has been in converting tools for research into tools capable of monitoring an actual treaty.

This has meant the installation of new arrays, the gradual improvement of the noise characteristics of instruments, the search for better sites, the establishment of centers to receive data in real time, improvements in the preparation of bulletins and so on. There is perhaps a need for a grand synthesis. As luck would have it, the past two years have seen three major and very different efforts in this direction.

The first was Bolt's *Nuclear Explosions and Earthquakes: the Parted Veil*, a book aimed at a wide audience and fairly free of technical language. Bolt is an Australian now working at Berkeley, and is as well qualified as any, scientifically, to write on the subject. He also writes clearly and entertainingly and has one outstanding advantage: his research only peripherally touches nuclear testing. If this gives one the impression that nuclear tests are of value in terms of the information they yield about the earth's core, it also gives a distinctive and perceptive view of the to-ings and fro-ings which I, for one, found valuable.

A very different book is *Monitoring Underground Nuclear Explosions* by Dahlman and Israelson. These authors have none of Bolt's freedom. They are Swedish Defense civil servants, and the Swedes have taken this whole business of a test ban very seriously It must, unfortunately, be said that the book does indeed read as if it were written by civil servants—scrupulously accurate in its reporting and thoroughly comprehensive. Many sides of a technical disagreement are fairly presented, but rarely do the authors come off the fence.

They are even more cautious when it comes to describing the political scenery. A longish chapter devoted to this is really little more than extracts from different countries' official statements. It is difficult, for instance, to deduce from Dahlman and Israelson the essential geographical and social asymmetry between the United States and Soviet Union that has colored all past negotiations. The authors no doubt hope that their book will become a reference work to supplant the old SIPRI report, and they have certainly done well in providing dispassionate reporting. But for the layman there is really only one choice—Bolt.

A document of a very different sort, however, has recently emerged from the Conference of the Committee on Disarmament (CCD/558). While the United States, the Soviet Union and Great Britain have been negotiating in private, a CCD group with representatives of 25 nations has been wondering what sort of network of instruments, what sort of data analysis center, what sort of

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international collaboration might be needed to satisfy monitoring requirements under a test ban.

The report, necessarily modest in tone, is remarkable not so much for its conclusions but for the first signs of serious Soviet collaboration. The commitment of the Soviet Union to any verification scheme involving the provision of data taken on Soviet soil has always been highly questionable. For instance, although it is traditional for seismologists to supply each other with seismograms on request for the purpose of special studies, records from the Soviet Union are unavailable for the days of Soviet nuclear tests (in contrast to the easy availability of U.S. records of Nevada blasts). In this report, for the first time we see clear signs of a change in attitude.

It is one of the diversions of the seisomological world to devise computer programs that will allow you to place imaginary seismometers anywhere on the globe, assign any noise statistics to them you choose and determine what seismic events are recorded just above the noise level at a sufficient number of stations to constitute a detection. This armchair surveillance of the world has over the years revealed the weaknesses of a global network to which the Soviet Union declines to contribute.

Even at the start of the CCD discussions there was no sign that the Soviet Union was prepared to be accommodating. But real progress has been made; by the end of the group's deliberations five seismic stations in the Soviet Union were being plugged into the computer programs. They will not be available for international monitoring use until a treaty is signed, but thereafter we can look forward to just a little data dribbling out. This makes the establishment of some sort of international data center much more sensible.

What can we distill from twenty years of research and these three very different documents? Can it all be summed up in a few paragraphs? The scientist in me says no, but the journalist in me says that it had better be brief and to the point. Here is my attempt:

Political necessities make it most unlikely that seismic instrumentation will be accessible in any country actually violating a comprehensive test ban. Most research has been devoted to non-intrusive monitoring, reckoning that a firing country might be able to ensure that no seismic data are available for closer than 1,000 kilometers to the test site. Under these restraints there is an excellent chance that an explosion of magnitude 4.0 or greater on the Richter scale would be picked up and located to within 50 kilometers or less. This magnitude corresponds to a kiloton or two fired in hard rock. At this low end of the scale large arrays of a hundred or more sensors spread over an area of up to 100 kilometers play a major role both in noise suppression and in pinpointing the source of signals.

Occasionally earthquakes give explosion-like signals, so identification of signals as coming, unambiguously, from an explosion is less easy, to ascertain; that requires higher quality data over a broader spectrum. For nearly all explosions of a yield greater than ten kilotons in hard rock these identification procedures can be successfully carried out.

Techniques for on-site inspection have on the whole been disappointing, partly because the seismic method cannot pinpoint a suspicious event precisely. No doubt satellite photographs would help. Other non-seismic methods for monitoring have yielded little of interest.

The constraints of a comprehensive test ban are necessarily unsymmetrical. If the United States were to sign and ratify such a treaty the scope for clandestine testing would be very limited. Anyone is at liberty to put seismometers down almost anywhere they choose and circulate the data as they choose. The thresholds for detection and identification would be much lower for a network that could get within 100 kilometers or so of any test. Of course, some will maintain that a test even of a yield of a few tons might be valuable and that seismic monitoring will fail at this level.

This must be set in contrast with the Soviet Union, where unofficial sources of seismic information do not exist and records from the official nationwide network are at present unavailable to foreigners on days that tests are fired. Thus if the Soviet Union did choose to test in violation of a comprehensive test ban—and I have no idea whether they would—they would certainly have only a 1,000-kilometer threshold to worry about.

The United States, Great Britain and the Soviet Union may well be able, in the next few months, to find a formula for a comprehensive test ban, even though this will probably mean the Soviet Union temporarily renouncing its peaceful nuclear explosions program. The three powers may then be able to present the treaty to the awaiting nations for signature without any serious attempts to modify the text.

But there is still one final hurdle. Such an agreement would have to be ratified by the U.S. Senate, and this can hardly be taken for granted. The weapons laboratories, if no one else, have every reason to subject the treaty to a very skeptical look.

There are certain to be questions raised about the thresholds for monitoring in the Soviet Union—"What? You can't guarantee that *every* clandestine test could be detected?" There is also bound to be a certain amount of interest shown in evasion techniques, and by a peculiar irony it is the U.S. weapons laboratories that have been encouraged in recent times to study evasion.

It is undeniable that there are various means of making detection and identification more difficult. The simplest (so simple that it is already widely used—for convenience, not for evasion) is to fire shots in softer rocks. The thresholds I quoted

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above have all been carefully described for hard rock, granite and the like. But an explosion in a softer rock will dissipate some of its energy simply in compacting that rock, so there will be less available to generate seismic waves. Reductions in signals in this way by factors of from 2 to 10 are regularly reported, although to get anywhere near a factor of 10, dry sand or clay several hundred meters deep must be found. The general feeling is that for small tests drastic signal reductions are possible, but above about 10 kilotons the required depth of burial becomes too great. Even so, for larger blasts it is probably not too difficult to find sites where the seismic signal is cut to half what it would be if the firing were in hard rock.

The ultimate in muffling the signal is to fire in a large hole. This eliminates the complex near-shot processes of rock—vaporization, plasticity, fracture and so on—and can cut the seismic signal by a factor of hundreds. To "decouple" a ten-kiloton shot at a depth of a kilometer, a hole about 90 meters in diameter is needed. Some large blasts themselves leave holes in which much smaller blasts could possibly be fired; or a salt dome might be leached out. Big-hole decoupling has been a problem in test-ban discussions since 1960, and will no doubt continue to be.

An alternative means of evasion is to wait for a large earthquake and fire in the backwash of it, when the world's seismic network has great difficulty in detecting small signals. Yet another is to fire several shots almost simultaneously in mimicry of an earthquake. Research has, of course, also been directed at countermeasures to these techniques. It wouldn't surprise me either if there were an evasion technique or two still up the sleeves of the weapons laboratories.

I cannot believe that in the hundreds of tests the United States has fired in the past fifteen years some other new ideas have not been tried out, such as possibly the packing of a device into a jacket of energy-absorbing material to simulate dry sand or clay deposits.

Should evasion be regarded as a very serious issue that might undermine hearings on a test ban? That is one of the tantalizing questions that one can do little to answer. Some scientists can say that evasion is possible if enough resources are devoted to it. Other scientists can point to the non-negligible risk of detection by some means or another. If a majority of politicians really want a test ban they will decide to live with the possibilities of evasion. If not, evasion could loom very large in Senate discussions.□

David Davies is the editor of Nature. *From 1970-73 he was group leader of the MIT Lincoln Laboratory's team studying seismic monitoring of explosions.*

LES ASPIN reviews

Soviet Civil Defense
by the Director of Central Intelligence
Report NI-78-10003, July 1978
13 pages

After a 15-year hiatus, civil defense is once again a major issue in the national security debate. This renaissance has been prompted by reports of an allegedly massive Soviet civil defense program, which, some analysts assert, could thoroughly degrade our deterrent capability.

A major document in this debate is the (unclassified) CIA report of last July. Most mass media summaries of the study have substantially distorted its contents. They have emphasized the following points:

- The Soviets spend $2 billion a year on their program;
- their entire political leadership, 12 to 24 percent of the essential workforce and 10 to 20 percent of the urban population could be protected in blast shelters; and
- under certain circumstances, sheltering and evacuation could keep casualties down to the "low tens of millions" in the face of U.S. nuclear retaliation following a Soviet first-strike.

The CIA study does say all this, but its basic theme—largely ignored—is that Soviet civil defenses could not decisively affect the strategic balance. In fact, the full conclusions of the study *undercut* those points listed above.

Soviets spend $2 billion a year. The CIA reports that the $2 billion a year figure was derived not from an exchange-rate calculation, but from how much it would cost the United States to duplicate the same program. It "does not reflect the economic burden to the Soviets" because 70 percent of this dollar estimate consists of manpower costs, assuming that Soviet civil-defense workers are paid a GS-7 or -9 level when in fact they are paid far less. (Only 40 percent of the 400-million ruble estimate is devoted to personnel.) Higher manpower costs in the United States significantly inflate the budget estimate. The CIA warns that the "estimates should be considered rough approximations . . . affected by uncertainties both in the quantitative data on civil defense programs and in estimates of prices."

Using dollars or rubles as an indicator of the Soviet civil defense effort is, in other words, both tenuous and misleading.

Urban shelter protection. The CIA makes unreasonably conservative assumptions about urban shelter protection. Their lower-range estimates (that shelters could protect 10 percent of the urban population, including 12 percent of essential workers) assume shelter occupancy of one square-meter per person; the higher estimates (20 percent and 24 percent) assume one-half square-meter per person. Both seem highly unrealistic, particularly if people must remain in shelters for days or weeks. Shelter experi-

ments conducted by the U.S. government in the early 1960s lend no credence to these assumptions.

Moreover, best-available shelter space is assumed, even though urban shelters vary considerably in protection-factor and in distance from targets. Estimates of the shelters' blast-resistance are probably overrated; at best, they might be correct for shelter walls, but almost certainly not for doors or ventilation systems.

Further, many of the shelters are in basements. They may provide some protection, but if the building itself collapses due to blast, many will be killed or severely wounded due to crashing debris or to blast and radiation from the explosion that tore apart the surface structure. (There would no longer be a roof protecting the occupants from these effects.)

The CIA report seems to have neglected the consequences of limited food, water and sanitation facilities. It also ignored reports from Oak Ridge that air-filter specifications in Soviet civil defense manuals are insufficient for absorbing carbon-dioxide or controlling heat and humidity.

Keeping casualties to low tens of millions. The CIA acknowledges that the estimate of casualties in the "low tens of millions" rests on highly dubious assumptions, most particularly that the United States would keep its forces on normal alert status while the Soviet spent a week or longer conspicuously evacuating their cities. If the United States surged its forces with only two days' warning, we could increase the number of warheads on-station (in the mid-1980s) by more than 50 percent and almost double deliverable megatonnage, thus producing greater fallout-intensity. Relaxed assumptions, still resembling a pessimistic (but not utterly absurd) case, would probably result in at least 20 to 40 million Soviet fatalities, even with very successful sheltering and evacuation.

Most important, the CIA concludes that "Soviet measures to protect the economy could not prevent massive industrial damage." Since U.S. targeting doctrine emphasizes destruction of industrial and military targets, not population per se, this means that Soviet civil defense could not degrade our deterrent capability and could not substantially alter the strategic balance.

The CIA confirms what some private analyses have claimed. Apathy about civil defense is widespread. No massive evacuation rehearsals have been held. Plans for dispersing and protecting industry have not been implemented; in fact, industry is becoming increasingly concentrated and several sectors increasingly vulnerable. Post-attack recovery would be thwarted by severe transportation difficulties.

Finally, Soviet civil defense has its roots in the World War II experience and in traditional emphasis on homeland defense. The Soviets' purpose is not aggressive, but "to convince political enemies that they cannot win a war with the USSR." The CIA does "not believe that the Soviets' present civil defenses would embolden them deliberately to expose the USSR to a higher risk of nuclear attack."□

Les Aspin, a member of the U S Congress from Wisconsin since 1971, serves on the House Armed Services Committee.

DAVID RITTENHOUSE INGLIS reviews

Blowing on the Wind: The Nuclear Test Ban Debate, 1954-1960
by Robert A. Divine.
Oxford University Press, 1978
402 pages, $14.95

There were two quite separate motivations for seeking a nuclear test ban agreement. One was to reduce the atmospheric burden of radioactivity with its much-debated somatic and genetic effects. The other was to reduce the likelihood of nuclear war by taking a small but significant step in arms control. After frustrations over more drastic steps, this seemed to be the step most nearly within grasp, as it still does.

Divine's narrative places more emphasis on the first than the second, which reflects the coverage in the contemporary press. The actualities of fallout impressed the public more than did vague talk of probabilities, particularly those of a holocaust beyond imagination. The rejoinders he traces seem almost endless between two viewpoints: that fallout radioactivity from tests is a health risk and that doing without weapons development requiring tests would be a greater risk, representing a loss of national security.

There is too little indication that behind these rejoinders there lay the deeper question of what constitutes security in an era of threatened mutual annihilation between a growing number of powers and whether that security would be increased by a test ban retarding nuclear weapons development and proliferation. Some conservative national leaders are seen to be deeply motivated by the security aspect, yet public and world concern over fallout seems to have been more influential in pushing them towards the test ban they never quite achieved.

In those early post-Stalin years covered by the book, the era of President Eisenhower and Premier Khrushchev, the threat of the H-bomb was new and so were the ideas about curbing it. Divine tells the story as seen from within the U.S. Administration, as well as by the public. His account is particularly valuable because it has the benefit of various recently released documents as well as wide coverage of the contemporary press.

There were three or four occasions when Eisenhower's view, and with it our negotiating position, favored a test ban, and agreement with the Soviets seemed hopeful until extraneous events shattered these

hopes. A possible first time was, ironically, when Adlai Stevenson preempted the test ban issue in the election campaign at a time when secret negotiations may have been critical. The next was the idea of a clean bomb with which Edward Teller and Lewis Strauss dazzled the President and (Divine fails to say) caused him suddenly to withdraw the U. S. negotiating position just after the Soviets had come surprisingly close to accepting it. Then came Sputnik and, finally, the shooting down of the American U-2 spy plane. It took an Eisenhower to stand up to the automatic objections of the Pentagon and he was a bit slow in deciding to do it.

The story covers the various events and technical developments that accompanied the political arguments. Among them were: the grand entrance of the H-bomb and Ralph Lapp's ingenious peering past a curtain of secrecy to increase public awareness of its threat; the controversy over fallout with the name Linus Pauling prominent; the advent of underground testing and subsequent Teller inventions that added to the difficulties of test-ban monitoring; and Hans Bethe's countervailing perseverence in devising and promoting ways to make monitoring effective. Other prominent figures were Harold Stassen who promoted a test ban through negotiation long before Dulles came to favor it and later the two K's from Cambridge, James Killian and George Kistiakowski, who as presidential science advisors did much to reconcile the technical difficulties and the political advantages in the minds of top officials.

Despite its skeptical title and a despairing note in the epilogue, the book gives a good and interesting, if not quite complete, account of an important early stage of what it fails to identify as a continuing quest for an effective test ban. It should be read as history and for the lessons of history. Fifteen years after the partial test ban removed the public pressure to stop the fallout from tests we are still faced with the challenge and the opportunity of a comprehensive test ban.

Times have changed. Deterrence between the two major powers has endured and is now based on an overkill so stupendous that, in any rational view, some inequality of advances in weaponry could not upset it. The art of seismological observations of underground tests has advanced enormously and adequate monitoring from afar is now practical. The proliferation threat has become a matter of current urgency. Plutonium is being produced increasingly rapidly in reactors all over the globe. Safeguards against diversion are inadequate. A comprehensive test ban is almost the only hope of inhibiting the development of nuclear weapons in many countries. Such restraint between the major nuclear powers is needed to bolster the nonproliferation treaty, in which they agreed to negotiate limitations on the arms race in return for nuclear abstention by the non-nuclear powers.

With these additional reasons for urgency and with the Soviets apparently more open than they were through most of those earlier times, it should be less difficult now to negotiate a meaningful test ban. Yet there is still the same contention between those whose faith is in ever more arms and those who see proliferating nuclear arms competition leading to disaster. At crucial junctures the Pentagon can still always press the need for one more weapon.

Can we achieve a complete test ban now, when it again seems politically the most likely next step in meaningful arms restraint? Divine's fine chronicle of the frustrations and quirks of fate that blocked a test ban long ago should be read with this question in mind.□

David Rittenhouse Inglis is professor of physics at the University of Massachusetts.

RICHARD SCLOVE reviews

Risk Assessment Review Group Report to the U.S. Nuclear Regulatory Commission
by H. W. Lewis and others
U.S. Nuclear Regulatory Commission (NUREG/CR-0400), 1978
Available from National Technical Information Service, Springfield, Va.
66 pages, $5.25; $3.00 microfiche

It has been over three years since the U.S. Nuclear Regulatory Commission (NRC) issued its massive Reactor Safety Study (known also as RSS, WASH-1400, or the Rasmussen Report), claiming at the time that the "report is a soundly based and impressive work" which "provides an objective and meaningful estimate of the public risks associated with" light water power reactors. The RSS' central conclusion was that reactor risks are very small compared to non-nuclear risks that society routinely accepts.

Now the commission has issued a new report severely criticizing the earlier study. Prepared by an NRC-appointed panel under the chairmanship of University of California Professor Harold Lewis, the new study finds that although the Reactor Safety Study was a "conscientious and honest effort," it nonetheless "greatly understated" the uncertainty of its estimates of the probability of severe reactor accidents, poorly described its analysis and results in its Executive Summary, and is generally "defective in many important ways." The criticism of the Executive Summary is especially important, because it is the part of the Reactor Safety Study most widely read by the public and decision-makers.

Among the Lewis Report's specific findings:

- The Reactor Safety Study advanced the state-of-the-art of quanti-

tative risk assessment and developed logical techniques that the Nuclear Regulatory Commission can use to help establish more effective research, inspection and regulatory programs.

- The statistical analysis which the RSS performed in conjunction with its use of these logical techniques is flawed—so deeply, in one instance, that it "boggles the mind."
- The RSS model of the consequences of reactor accidents requires substantial improvement.
- The final version of the Reactor Safety Study suffers because its authors either evaded or failed to acknowledge a number of cogent criticisms submitted by peer reviewers of a publicly released draft of the report.
- The nature of its deficiencies is such that it is not possible to determine whether severe reactor accidents are more or less probable than the RSS reports them to be.

The Lewis Report by and large succeeds admirably in evaluating a wide range of difficult issues within a very few number of pages. One broad topic is, however, conspicuously absent. Although the report includes detailed assessment of the RSS peer review process, nowhere does it discuss the overall process by which the Reactor Safety Study was undertaken or the political manner in which the study was used by the Nuclear Regulatory Commission and its predecessor, the Atomic Energy Commission (AEC).

Through information obtained under the federal Freedom of Information Act it is now known that the Reactor Safety Study was initiated in anticipation of an upcoming congressional vote on whether or not to renew the Price-Anderson Act—legislation through which the federal government participates in the insurance of commercial nuclear reactors and sets an upper limit on electric utilities' public liability in the event of a major reactor accident. As the Act gradually worked its way through the congressional committee system in 1974–75, the AEC/NRC first briefed members of Congress on a draft of the Reactor Safety Study without disclosing internal criticism by AEC reviewers, rushed completion of the report to coincide with congressional

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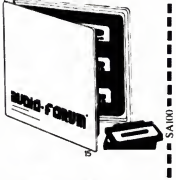

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schedules, and then presented the final report to the Congress without mentioning that interested scientists who had asked repeatedly to see the final document had not yet been provided with copies. Such matters are not addressed in the Lewis Report, but just one measure of their significance is that some of them were discussed by the commissioners themselves at an October 13, 1978 NRC meeting devoted to the review group report. While not directly bearing on the validity of the RSS' conclusions, these issues are vital to the general question of the role of government agency reports in the political process and in public policy formulation.

The Reactor Safety Study is and always has been controversial, in part because of the way in which it was undertaken and used. In organizing an evaluation of the Reactor Safety Study, the NRC should have learned its lesson and taken every reasonable precaution to ensure that the Lewis Report would not become similarly embroiled in unnecessary and counterproductive political turmoil. Regrettably, the lesson appears to have gone unheeded.

Notwithstanding a commendable effort by the NRC to secure a relatively balanced RSS review group, a number of potential conflicts of interest permeate the process by which the Lewis Report came to be written. For example, the commission allowed the same employee who had served as staff director of the Reactor Safety Study, Saul Levine, to select the chairman of the RSS review group and, in participation with Dr. Lewis, to draft the group's charter and to choose its members. Then midway through the review group's deliberations the commission initiated negotiations with (and ultimately hired) one of the Lewis panel's members, Robert Budnitz of Lawrence Berkeley Laboratory, for a job as Mr. Levine's deputy. While the review group's performance may not have been compromised in any way, the NRC would have been wiser to have avoided any possible appearance of conflict of interest.

Although the Reactor Safety Study has been widely quoted and frequently cited in support of commercial nuclear power programs in the United States and abroad, it has also been extensively criticized in the past, and thus most of the Lewis panel's conclusions are not new. However because its findings represent the considered judgment of a group of NRC-selected expert evaluators, the Lewis Report is noteworthy and will carry weight. It is therefore fortunate that its authors, who at times disagreed sharply while deliberating, have managed to produce a consensus document that is concise, well-organized and generally clearly reasoned. Although scholarly documentation is omitted, some passages are ambiguous, and a few potentially important topics are overlooked, the panel has probably performed about as well as could be expected in tackling a complex and controversial subject within a limited period of time.

Apart from Lewis and Budnitz, the other members of the Risk Assessment Review Group were Herbert Kouts, Brookhaven National Laboratory; Walter Loewenstein, Electric Power Research Institute; William Rowe, U.S. Environmental Protection Agency; Frank von Hippel, Princeton University; and Fredrik Zachariasen, California Institute of Technology. □

Richard Sclove is a graduate of the department of nuclear engineering at M.I.T. He is currently assistant to the chairman of a Ford Foundation/Resources for the Future, Inc. Study Group on "Energy: The Next Twenty Years." The views expressed in the review are his own.

JOHN DOWLING reviews
Nuclear Countdown

Produced by Ramakantha Sarma for United Nations Productions. Distributed by Journal Films, Inc., 930 Pitner Ave., Evanston, Il. 60202. 16mm. color, 28 min. Price: $365 purchase. Released 1978.

Nuclear Countdown is a documentary film of the nuclear arms race from 1945 to the present that is designed to raise public awareness of the need for nuclear disarmament. The purpose and thrust of the film is clearly stated by U.N. Secretary-General Kurt Waldheim:

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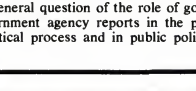

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"The nuclear arms race and its inherent threat of ultimate disaster is by far the greatest peril the world faces today. It is my firm belief that this danger can only be averted by halting development and production of nuclear weapons and eliminating existing stockpiles. The United Nations has a vital role to play in bringing this to the attention of the world community and encouraging urgent action."

Nuclear Countdown sketches the history of the nuclear arms race. Film clips show important principals and events—the Baruch Plan, Gromyko's response, each entry into the nuclear club, India's 1954 nuclear testing standstill proposal, Ike's Atoms for Peace, the moratorium and the 1963 partial test ban treaty, the Cuban missile crisis, Treaty of Tlatelolco, bilateral agreements creating nuclear free zones, and the 1968 Non-Proliferation Treaty—while the narrative explains their significance. Curiously omitted was SALT and the Vladivostok agreements. The overview of the dangers of nuclear weapons proliferation includes problems associated with the increasing nuclear power capability of nations: radioactive waste disposal, terrorism, theft and diversion of fissionable materials and diversion. There is a sober account of the successes, failures and inadequacies of the agreements to date.

The film provides a humanistic perspective of the arms race. It shows the candle floats at Hiroshima ("They came to remember, so we will not forget") and the protests against atmospheric testing (with John Lennon's "Give Peace a Chance" as background music). It covers the diversion to military spending of the money, talent and resources needed to solve the problems of a starving illiterate world. All of these scenes are countered with innumerable shots of missiles, airplanes, submarines and mushroom clouds.

Nuclear Countdown offers a good overview of the nuclear arms race. It should be the introductory film of a series on the arms race. The film's necessarily too brief survey of events could be expanded. It does not accuse, it places no blame.

If we are to get beyond platitudes to actual disarmament, we must get concerted action via a public that is informed about the arms race—and outraged at its irrationality and insanity. *Nuclear Countdown* is technically good. It is worth purchasing by any group seeking to inform the public about the arms race. □

John Dowling, Jr., professor of physics at Mansfield State College in Pennsylvania, is the film editor for the American Journal of Physics.

Space—Battlefield of the Future?
by Bhupendra M. Jasani
SIPRI, 1978
202 pages, $8.00

In this handsome volume from SIPRI, B. M. Jasani, the careful and conscientious SIPRI researcher who in the past has contributed chapters on military uses of space in several SIPRI yearbooks, brings together a wealth of information on the various military uses of outer space.

After equipping the reader with the necessary information on orbit dynamics (Chap. 2), Jasani proceeds systematically to describe the various classes, uses and performance of the satellites lofted into orbit by different nations since the beginning of the Space Age. Consecutive chapters describe military reconnaisance, communications, navigation, and meteorological, geodetic and interceptor/destructor satellites. Every chapter is followed by an appendix with judicious listings of the known orbital and mission characteristics of each spacecraft. This is a useful and handy guide into the military space programs of both superpowers, complemented by understandable explanations of the concepts of operation and use involved in each class of satellite.

The author avoids discussing the more technical performance characteristics and technologies involved in the payloads of these satellites, and consequently it is hard for the reader either to assess the relative state of technological sophistication embodied in such payloads or to project future performance trends. But Jasani also carefully and refreshingly avoids any biased statements or the anti-military and gloom-and-doom phraseology that one sometimes encounters in SIPRI publications. In sum, Jasani's book is the kind of useful technical treatise on a timely and important matter that we expect from SIPRI.□

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60 Minutes on particle beam weapons

The following letter was sent to Mr. Don Hewitt, Executive Producer of 60 Minutes, *at CBS in New York on December 18.*

Dear Mr. Hewitt:

I was glad to meet you at the Council on Foreign Relations the other evening, where we were introduced by Marilyn Berger. I must say that I was disappointed in the treatment *60 Minutes* gave the particle beam weapon.

It might be instructive to you to compare the unedited script of the answers I gave during my 11-minute film interview with Harry Reasoner against the portion which was actually shown. Almost all of my responses were addressed to the *substance* of what General George Keegan was claiming. What you showed on the show was my response to a question which was not even voiced!

Furthermore, the segment ends with a mention of a report "soon to be published" by a study group led by Richard L. Garwin. I have already published my views on the particle beam weapon (and sent a copy to your staff) in the October 1978 *Bulletin of the Atomic Scientists.*

The reasons why the particle beam is not practical as a strategic defense weapon are quite simple, are stated in my interview with Harry Reasoner, and are clearly stated in my October 1978 publication. Whose decision was it not to show a single substantive comment as to why the particle beam need not be feared as a means of "eviscerating" our strategic deterrent?

Incidentally, General Keegan has long had my publication of October 1978 (which I sent him June 3, 1977 in a version widely distributed at that time.) He did not then and has not since answered any of the criticisms.

I enclose the text of the original interview as I recorded it myself, together with the quotes as broadcast. For your information, as well as for those on the copy list, I enclose also my October 1978 publication on this subject.

Sincerely yours,
Richard L. Garwin

Interview
Harry Reasoner with R. L. Garwin
November 17, 1978

Reasoner: Dr. Garwin, General Keegan believes that for many years, maybe 20 years, the Soviet Union has been hard at work developing a particle beam weapon. I gather you disagree. Why?

Garwin: Well, I've looked at the same information Keegan has, and I've seen the story which he gave *Aviation Week,* published May 1977, and it really doesn't hang together. Naturally they've been interested in charged-particle beams and any other kinds of weapons, as have we. If they've been working on it for 20 years, they've been doing it *very* slowly and not very effectively.

But the particular complex that Keegan talks about, at Semipalatinsk, is supposed, according to his story, to be a place where they use nuclear explosions to power charged-particle beam weapons under development. I maintain in my publications in response to those stories that anybody would be out of his mind to use nuclear explosives to power charged-particle beams. They just don't work for that. They have the wrong characteristics. So whatever the charged-particle beam aspect, the combination of things that Keegan puts together just doesn't make any sense.

Reasoner: You're touching on a thing that is very close to the problem with this story. It is that you can get scientific disagreement on whether this is the right way or the possible way to do something, plus what General Keegan says, which is that the opposition comes from people for political reasons (maybe good political reason) not to destroy American-Russian détente. How can lay persons like myself, or the people listening to you now, judge the validity of the *scientific* conclusions before they go into the political conclusions?

Garwin: I just published an article in the October 1978 *Bulletin of the Atomic Scientists* discussing charged-particle beam weapons. I talk about the various applications for which they could be used, in principle for defense against ballistic missiles; they could be used ground-based or based on satellites in space. They've been talked about and we have a program in the U.S. government for investigating them for defending ships against cruise missiles.

Some of these—the satellite-based charged-particle beams—just don't work. You have either charged-particle beams or, under the same name, you have neutral-particle beams. One of them has one kind of problem (bending in the earth's magnetic field); the other has a different kind of problem (the inability to penetrate a little bit of atmosphere which could be raised as a defensive mechanism).

The ground-based charged-particle beam for ABM (ballistic-missile defense purposes) has to compete with the other things that we could use for ABM, and it would fit into a system which included radars, trackers, computers, communications. It would replace just the interceptor—the nuclear-tipped interceptor usually or a non-nuclear-tipped interceptor. And for that purpose it's a very poor way of doing the job.

For defense of ships against non-

nuclear-armed cruise missiles, my own prediction is that, when analyzed, we will find better ways based upon conventional missilery and that the charged-particle beam investigation will prove to be a necessary but expensive diversion.

Reasoner: What you're saying is that the idea of using a nuclear explosion to start the process which would result in a particle beam weapon is not practical, and you doubt that the Russians are doing it.

Garwin: I say *that's* nonsense.

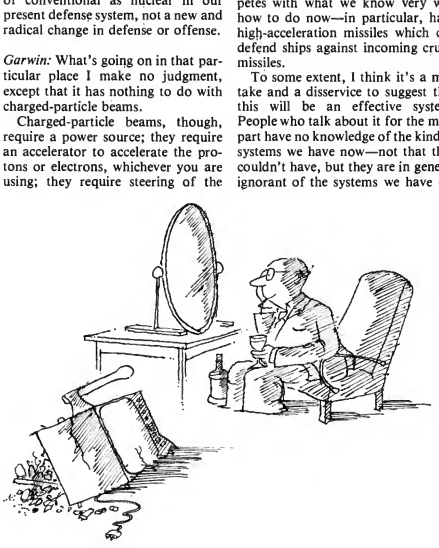
Reasoner: You're saying that it might be a part of another chain of more or less conventional weapons, speaking of conventional as nuclear in our present defense system, not a new and radical change in defense or offense.

Garwin: What's going on in that particular place I make no judgment, except that it has nothing to do with charged-particle beams.

Charged-particle beams, though, require a power source; they require an accelerator to accelerate the protons or electrons, whichever you are using; they require steering of the beam against the target; they require something to find the target and to communicate.

In defending against any of these systems, when you talk about weapons you talk about countermeasures as well. A charged-particle beam system, or any interceptor no matter how effective, is useless unless you can communicate with it. In the past we have often used electronic countermeasures, jamming, destruction of communication links, all kinds of ways, to disable weaponry which at first sight might look effective. But here we haven't gotten to first base in proving the capability of generating the beams, steering them, moving them through the atmosphere, let alone having something that competes with what we know very well how to do now—in particular, have high-acceleration missiles which can defend ships against incoming cruise missiles.

To some extent, I think it's a mistake and a disservice to suggest that this will be an effective system. People who talk about it for the most part have no knowledge of the kind of systems we have now—not that they couldn't have, but they are in general ignorant of the systems we have deployed and in advanced development for ship defense.



Reasoner: The United States now is spending probably what this year, maybe $24 million, at various sites and expects to spend, according to our sources, maybe a billion dollars within the next 10 years on research in high-energy, directed-energy weapons. Is that a mistake too?

Garwin: Well, directed-energy weapons include lasers as well. I think the $24 million—if that's right for this year—in charged-particle beam weapons is money well spent, even if it shows us that there is no promise there. Because very often you spend money not to build something but to find out that it can't be done, that the other side can't do it either. So I support this program.

I think that the Defense Department is finally doing a reasonable job in the charged-particle beam field, looking not just at the generation of intense beams of particles, but also at the rest of the system that's required, to steer and track and determine the miss distance, and to have radars or other elements which will direct the beam effectively against the target.

Reasoner: One of the implications of people who defend particle-beam weapons as a feasible development—one of the implications of the things they say is that there is a kind of an "old-boy network" among American scientists who fall into the "we didn't invent it so it doesn't exist" syndrome. Are you part of an "old-boys network," Dr. Garwin?

Garwin: Nobody has ever accused me of being unreceptive to technical advances or developments. No, I make my own; I continue to invent things; and I admire whatever comes along that anybody else has invented.

Reasonser: But there is a kind of a split. If you took a hundred top American scientists with credentials equal to yours, some of them would

disagree with you quite sharply about this kind of a weapon, wouldn't they? I mean, there is a split?

Garwin: I doubt it. I think most of the scientists with contact with this field would agree with me. They might not be so outspoken about it. You might find a few. I think the argument is quite the opposite: that *all* the old boys are against it and only young Turks are in favor.

Reasoner: Where would you be, halfway between the old boys and young Turks?

Garwin: I just judge things on their merits, on their feasibility and their utility. And it's premature to judge: we have to do some more work. But if I have to predict, I will bet that charged-particle beams will not be an important part of the weaponry of the United States or the Soviet Union in the next 20 years.

Reasoner: But as I see it, both as a scientist and as a taxpayer, you have no objection to the money that's being spent on it at the moment?

Garwin: Not to the $20 million types of money. You can do all kinds of things with that, and what we find out about accelerators or the feasibility of radars or hardened communication systems can be used in other ways.

The billion dollars you talk about is, I suppose, what the Defense Department has put together as a proposed program in case they prove to have success in the early years. You can't go into a program and say, "I'm sure it's going to fail and therefore I don't have to devise any budgetary projections for the out years." They want to know how much it will cost really to develop the thing, and after that it will be probably 15 years or 20 years even if it were a very conventional weapon before it goes into the arsenal. It takes a long time to do these things; it takes a long time for the Soviet Union to do them too. In fact, General Keegan says that it's already taken them 20 years and they obviously don't have anything.

Reasoner: You don't think we are in serious danger of being overwhelmed with a major new weapons system by the Soviet Union:

Garwin: Absolutely not!

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Garwin's Comments as Broadcast December 17, 1978

Reasoner: Sour grapes does not wholly explain why a considerable number of American scientists genuinely hold that this kind of particle-beam research will never produce a weapon. Physicists like Dr. Richard Garwin of IBM . . .

Garwin: If I have to predict I will bet that charged-particle beams are not going to be an important part of the weaponry of the United States or the Soviet Union in the next 20 years.

Reasoner: But there is a kind of a split between fully qualified scientists.

Garwin: I doubt it. I think most of the scientists with contact with this field would agree with me. They might not be so outspoken about it. You might find a few. I think the argument is quite the opposite: that *all* the old boys are against it and only the young Turks are in favor.

Reasoner: One scientist who may with respect be called an "old boy" is Dr. Edward Teller . . .

On cancer and low level radiation

BERNARD L. COHEN

What is the misunderstanding all about?

The September 1978, issue of the *Bulletin* carried two articles on induction of cancer by low levels of ionizing radiation by two well-respected members of the radiological health community, Karl Z. Morgan and Joseph Rotblat, and each carried the message that recent research indicates that the carcinogenicity of low level radiation is much higher than had been previously believed. Karl Morgan states, "Most of us recognize that the risk of inducing cancer at low doses of radiation is far greater than we once thought it to be." Joseph Rotblat says, "The new knowledge indicates that the carcinogenic action of radiation is much greater than we thought earlier."

This theme has been repeated frequently in the public press, radio, and TV, and is now a standard weapon in the arsenal of those dedicated to the destruction of nuclear energy. The impression is given that all the estimates of the risks of nuclear power must be increased by a substantial factor, and that these estimates will continue to increase with time.

On the other hand, the United Nations Scientific Committee on Effects of Atomic Radiation (UNSCEAR) in their 1977 report (referred to frequently by Morgan and Rotblat) gives the same estimates for carcinogenicity of low level radiation as were given in their 1972 report. The International Commission on Radiation Protection (ICRP) reported similar estimates in 1977, and both are slightly lower than the estimates given in 1972 by the National Academy of Sciences Committee on Biological Effects of Ionizing Radiation (BEIR Report 1972). I have discussed this question with many members of the involved scientific community and with just one exception, none of them agree with the implications of the Morgan-Rotblat statements quoted above. What is this misunderstanding all about?

When one reads the Morgan paper *carefully* there is not a great deal to which one can object. His principal argument is that many years ago it was widely believed that radiation-induced cancer has a threshold below which there is zero effect, whereas recent evidence seems to indicate that effects are still present down to rather low doses—in the vicinity of 10 rem—and that these effects of low doses are not grossly underestimated by assuming a linear dose-effect relationship based on well-established effects at high doses. With this interpretation, his statement quoted above is correct for alpha particle and neutron radiation, and may even be correct for beta and gamma rays.

However, the inference from it that the previous estimates of environmental impacts of nuclear power will have to be increased is *not* correct. For at least 20 years, these estimates have been based on the assumption of a linear dose-effect relationship, and the slope of the line in this linear relationship has not increased. Morgan's article does little to make that point clear.

He gives a table showing how the "maximum permissible exposures" have decreased with time, leaving the impression (but not stating) that these decreases were introduced because of new biomedical information. Actually these decreases were instigated by changes in public attitudes toward risk and by improving technology which made them practical. They were expressions of the long-standing policy of all advisory and regulatory groups that radiation exposures should be kept "as low as reasonably achievable," and each was the result of studies indicating that lowered standards were reasonably achievable, rather than of new biomedical information.

The Mancuso-Stewart-Kneale Paper. The most serious point on which most members of the radiobiomedical scientific community would disagree with Morgan is in his acceptance of the work of Mancuso, Stewart, and Kneale (MSK) on excess cancers among Hanford workers.[1] Rotblat also accepts it but I have yet to encounter a single other member of the involved scientific community (other than the authors) who does.

At least 15 critiques of the MSK paper have now appeared,[2] and it has been rejected by the International Commission on Radiation Protection,[3] by the U.K. National Radiological Protection Board, (*Bulletin* 23, 1978) and by the staff of the Nuclear Regulatory Commission. It is beyond the scope of this paper to summarize these critiques here. My

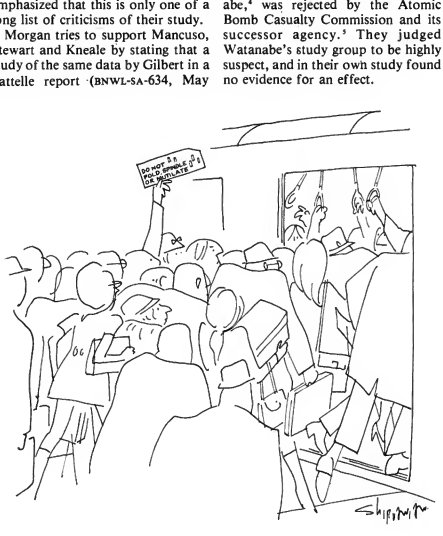
Editor's note: The articles on the biological effects of low level radiation by Karl Morgan and Joseph Rotblat, published in the September 1978 *Bulletin*, raise a number of serious questions on the adequacy of present radiation standards. This is a very controversial issue, which we had expected would give rise to considerable debate. So far, however, with the exception of the Cohen comment that follows, all the letters received have been essentially in agreement with Morgan's and Rotblat's criticisms of present accepted standards.

We are publishing the following comment by Cohen together with the responses from Morgan and Rotblat in the interests of a full airing of all sides of an issue that is not likely to be completely settled for some time to come.

favorite criticism is that MSK may have shown that among the Hanford workers who have already died, cancer was a more frequent cause of death for those who received higher radiation exposure, but there could easily be socioeconomic or occupational factors which are responsible for this. Those who received more radiation were largely operators and technicians who generally have higher cancer rates than "white collar" workers. Moreover, this group was exposed to various chemical carcinogens including asbestos, and it is generally believed that occupational exposures are among the most important causes of cancer. Mancuso, Stewart and Kneale made no effort to consider that factor. It should be emphasized that this is only one of a long list of criticisms of their study.

Morgan tries to support Mancuso, Stewart and Kneale by stating that a study of the same data by Gilbert in a Battelle report (BNWL-SA-634, May 1977) shows some effect; but this was principally for multiple myeloma and is largely based on the fact that two workers with high radiation exposures died of that disease. Gilbert certainly makes no claim that this is good evidence for an effect, and similar analyses would indicate that radiation *prevents* other types of cancer.

Another point on which the Morgan and Rotblat articles both diverge from the majority opinion is the excess leukemias they say were experienced by early entrants into Hiroshima and Nagasaki following the A-bomb incidents, presumably due to short half-life radioactivity from neutron activation products. This issue, originally raised by Watanabe,[4] was rejected by the Atomic Bomb Casualty Commission and its successor agency.[5] They judged Watanabe's study group to be highly suspect, and in their own study found no evidence for an effect.



A-Bomb Survivors vs. Medical Exposures. While Morgan seems to be roughly satisfied with current risk estimates if the linearity hypothesis is maintained down to zero dose, Rotblat goes considerably beyond him in strongly suggesting that these estimates, which have been endorsed and used by UNSCEAR, the BEIR Committee, ICRP, NCRP, British Medical Research Council, United Kingdom National Radiological Protection Board, and other official groups, are too small. His rationale for this is that data on the Japanese A-bomb survivors is generally given heavy weight in risk estimates, and he contends that they are about five times too low because they are that much lower than risk estimates obtained from medical exposures for breast, thyroid, and lung cancer (but not for leukemia) in the recent UNSCEAR Report. He believes that the A-bomb survivors are a select group in that they survived the injuries and trauma of the explosion and that data on them should therefore be discounted.

I would like to point out that this hypothesis implies that there would have been at least ten times as many cancers among those with high radiation exposure if they had survived, but few additional cancers among those with lower exposure since there were few early deaths among those a large distance away; this would imply that linearity grossly over-estimates effects of low doses, contrary to Morgan's principal argument.

But let us consider Rotblat's discrepancies between data on A-bomb survivors and medical exposures. This discrepancy has long been recognized in the case of breast cancer, and it is believed that it may be connected with the fact that breast cancer is normally four times less prevalent in Japan than in other advanced nations. In any case, usual risk estimates for breast cancer have always been based on medical exposures rather than on A-bomb survivors.

Thyroid cancer is rarely fatal so data on it must be obtained by less

reliable means than the mortality statistics used for all other cancers, and there are even considerable variations in what is classed as thyroid cancer. Nevertheless, the UNSCEAR summary states "there appears to be no obvious explanation for the thyroid cancer incidence difference" between A-bomb survivors and those exposed medically. Part of the explanation would seem to be that there is good evidence for enhanced effects in children and essentially all of the high risk data are for children. The only exception is Marshall Island natives exposed to fallout from a nuclear weapons test, although there is considerable uncertainty concerning the dosimetry for them.

The conclusion on lung cancer is based on a comparison with radon inhalation by miners which is a very different type of exposure than gamma rays from an A-bomb. The former is expressed in "working level months" (WLM) and there is a large uncertainty on how to convert WLM to rem, the unit of gamma ray exposure. Moreover, UNSCEAR gives the risk from miner data as 200-450 x 10^{-6}/WLM and a conversion factor of 1 WLM = 10 rem which should give a risk of 20-45 x 10^{-6}/rem, whereas in what I can only interpret as an arithmetic error, they conclude that the risk is 40-180 x 10^{-6}/rem and Rotblat uses the mean of these, 110 x 10^{-6}/rem. If 20-45 x 10^{-6} per rem were used there would not be much discrepancy with the data from the A-bomb survivors, 10-25 x 10^{-6}/rem. Incidentally, UNSCEAR gives nine possible reasons for the discrepancy, and these do not include the one offered by Rotblat.

If there is a discrepancy here, I would like to offer an alternative explanation. The average radiation exposures to the bronchial region of the A-bomb survivors were typically 30 times lower than those of the miners, and in fact were less than twice the average exposure of the general public due to radon in the environment. I have shown[4] that the linear dose-response assumption fitted to the miner data overestimates total lung cancer incidence among non-smokers in the general public. This means that linearity overestimates effects of low doses at least for lung cancer, and would explain why incidence among the A-bomb survivors may be lower than expected from linearity.

There is no discrepancy for leukemia between the A-bomb survivors and those with medical radiation exposures, which Rotblat attempts to explain in an unusual way. Actually the largest medical exposures historically were x-ray treatments for ankylosing spondylitis (an arthritic condition of the spine) in Britain which have caused about as many excess cancers as have occurred among the Japanese A-bomb survivors. These data are not given much consideration in the UNSCEAR Report which Rotblat relies on so heavily because the studies in it had not been updated for more than a decade. However, an update has now been completed and the results are quite consistent with those from the A-bomb survivors for all types of cancer.

In summary, Rotblat's conclusion, that effects on the A-bomb survivors are generally about five times smaller than effects from medical exposures, is a weak one. To the extent that it is correct, it could be explained by the possibility that sick people (that is, those medically exposed) are more susceptible to cancer than the average. The idea that the data on Japanese A-bomb survivors should be ignored is, to the best of my knowledge, unique to Rotblat.

Occupational Exposures. Both Morgan and Rotblat recommend that allowable occupational exposures be reduced, Morgan by a factor of two and Rotblat by a factor of 10; but neither gives a very quantitative argument on that subject, so let me supply it here.

The maximum allowable occupational exposure is now 5 rem per year, but the average radiation worker receives only about 0.7 rem, or a total of 30 rem in a 45-year career. His cancer risk from this is about 0.4 percent and his resulting loss of life expectancy is about 20 days. By comparison, the average risk of death in occupational *accidents* among all U.S. workers in a 45-year career is 0.6 percent resulting in about 70 days reduction in life expectancy. In some of the more dangerous industries like construction and mining, the risk is more than four times higher than this average. Moreover, these figures include only deaths resulting from accidents. If occupationally-induced fatal diseases were included, *the toll would undoubtedly be several times higher.* For example, a recent study indicates that more than 20 percent of male cancers result from occupational exposures to chemicals, which corresponds to reducing life expectancy by 200 days. Clearly, then, the 20 days of lost life expectancy from radiation exposure is not an unusually high occupational risk, especially since other risks to radiation workers are generally lower than average.

A radiation worker who receives the full 5 rem per year would have seven times the risk quoted above, but all of the occupational risks we have quoted are for averages rather than for those maximally exposed. In fact, they are averages over whole industries, including administrative and clerical workers. It would thus seem that a radiation worker is at least as safe as the average U.S. worker (and much safer than some) with present standards.

From the viewpoint of society as a whole, the total radiation exposure* in 1975 among the 55,000 workers at U.S. power reactors was 21,000 man-rem (this is an average of 0.39 rem per worker, but not all are classed as radiation workers), which is estimated to eventually cause 2.5 cancers. Extrapolating to the larger industry in the mid-1980s, we might expect about 10 fatal cancers induced per year.

It is estimated that reducing the maximum allowable exposure by a factor of ten would cost the nuclear

industry about $500 million per year and would *not* reduce total population exposures in man-rem, that is, it would merely distribute it among more people. But even if it would eliminate all exposures, it would be difficult to justify spending $500 million to save 10 lives when our society can save a life for every $25,000 spent on medical screening programs and for every $100,000 spent on highway or automobile safety devices. □

1. T. F. Mancuso, A. Stewart, and G. Kneale, *Health Physics* 33 (1971), 369.

2. E. S. Gilbert, *Battelle Northwest Laboratory Report* BNWL-SA-634 (May, 1977); S. Marks, E. S. Gilbert, and B. D. Breitenstein, IAEA-SM-224; A. Brodsky, Testimony to House Subcommittee on Health and the Environment, Feb. 8, 1978; L. A. Sagan, Electric Power Research Institute Report "Low-Level Radiation Effects: The Mancuso Study," 1978; *Atom*, No. 262 (August 1978); B. S. Sanders, *Health Physics* 34 (1978), 521; D. J. Kleitman, "Critique of Mancuso-Stewart-Kneale Report," Submission to Nuclear Regulatory Commission, March 2, 1978; J. A. Reissland and G. W. Dolphin, Radiation Protection Bulletin No. 23, England: National Radiation Protection Board, Harwell, 1978; "The Windscale Inquiry," London: Her Majesty's Stationery Office, 1978; T. W. Anderson, *Health Physics* (in print); U.S. Nuclear Regulatory Commission, Staff Committee Reports of Nov. 1976 and May 1978; D. Rubenstein, Report to Nuclear Regulatory Commission, 1978; C. E. Land, *Health Physics* (in print); B.L. Cohen, *Health Physics* 35 (1978), 582; R. Mole, *Lancet* (1978-I), 1156; S. M. Gertz, *Health Physics* 35 (1978), 723.

3. Minutes of 1978 Stockholm Meeting of the International Commission on Radiation Protection states, "the Commission has concluded that the information available up to May 1978 does not call for changes in the risk factor given in ICRP Publication 26." The MSK paper was published and widely publicized in November 1977.

4. S. Watanabe, "Cancer and Leukemia Developing Among the Atom Bomb Survivors," New York: Springer, 1974.

5. G. W. Beebe, H. Kato, and D. C. Land, Atomic Bomb Casualty Commission Technical Report 11-70 (1970); G. W. Beebe and C. E. Land, IAEA-SM-224/601 (1978).

6. A. F. Cohen and B. L. Cohen, "Tests of the Linearity Assumption in the Dose-Effect Relationship for Radiation Induced Cancer," *Health Physics* (submitted).

7. W. S. Cool, U.S. Nuclear Regulatory Commission Report NUREG-0419 (1978).

Morgan's response: Bernard L. Cohen's comment is replete with errors and misrepresentation of fact. First of all, Cohen is a bit careless in his references. He states that in my article in the *Bulletin* (September 1978) I referred frequently to the 1977 UNSCEAR report. I did not make a single reference to this report. Then again Cohen states, "at least 15 critiques of the MSK paper have now appeared. . . ." Of the 14 which he lists, 2 cannot be checked because they refer to unpublished papers by Cohen.

Cohen fails to mention that 3 of the remaining 12 papers contain independent evidence of a rising risk of two types of cancer of radiosensitive tissues with increasing dose received by the Hanford workers (see E. S. Gilbert, BNWL-SA-634, May 1977; S. Marks et al., IAEA-SM-224; and C. E. Land, *Health Physics*, in print) and 9 references to individuals who have either stated a preference for an alternative of a less efficient method of statistical analysis or (like Cohen) have yet to encounter anyone who agrees with our conclusions. This hardly amounts to serious (independent) criticism of the Mancuso, Stewart and Kneale data or their method of analysis.

Cohen goes to considerable length to impress the reader that the International Commission on Radiological Protection (ICRP) does not agree with the main thesis of my paper that the risk of exposure to low levels of ionizing radiation is much greater than we considered it to be some years ago. The main commission of ICRP is composed of 16 members (including myself as an emeritus member) from 9 countries. There is no doubt that there is, and always has been, a wide diversity of opinion on this question among these 16 members. For example, as I pointed out in my paper, one of these 16 members, H. J. Dunster of England (who probably, like Cohen, believes the risks of low level exposure to ionizing radiation are insignificant) suggested a risk value of a man-rem be set as low as $10 (*Health Physics* 19 1970, 121); this is to be compared with the value of $1,000 per man-rem now used by our more conservative Nuclear Regulatory Commission.

At the other end of the spectrum, one of the 16 members of ICRP is the very knowledgeable radiobiologist, A. C. Upton, whose judgment in these matters is highly respected as witnessed by the highly responsible position in public health which he holds in our government. He showed considerable foresight when in 1967 he stated:

"Since, however, susceptability to radiation-induced tumors is influenced by physiological variables, and since cancer presumably arises through the interaction of multiple contributing factors, it is conceivable that a single quantum of radiation may be carcinogenic in an appropriately conditioned individual. Furthermore, since radiation seems in many instances merely to hasten the onset of an otherwise spontaneously occurring cancer, evaluation of the effects of radiation on the incidence of malignant growth is by no means a straightforward statistical or biological problem." (A. C. Upton and R. F. Kimball, *Principles of Radiation Protection,* chap. 12)

It seems to me the ICRP in discussing effects of low level exposure (ICRP Pub. 8, 1966) was very much aware of the increasing cancer risk when it stated:

"Many types (of cancer) have been produced and the evidence is so extensive that it is reasonable to assume that all tissues—or very nearly all—are susceptible. Until recently, however, there has been little direct evidence to show that moderate levels of radiation can increase the incidence of tumors in many tissues of man in which cancer is relatively common under normal conditions, e.g. stomach, pancreas, colon,

rectum, breast, uterus, and bladder . . . ."

Then in 1971 ICRP in one of its working papers, entitled "Dose Limits for the General Population" (ICRP/71/L:C1-4), stated:

"Further observation of irradiated human populations may suggest that the total induced malignant disease will be an order of magnitude greater than the total of induced leukemia. It could be concluded that the ratio of somatic to genetic effects after a given exposure is 60 times greater than was thought 15 years ago."

Cohen (like so many of his associates in the "scientific community including some very prominent experts, and with one exception, none of them agree with the implications of the Morgan-Rotblat statements quoted above") is not willing to accept the fact that the data on radiation induced cancer among the Japanese survivors of the bombings in Hiroshima and Nagasaki probably greatly underestimates the cancer risk from radiation exposure because of the concurrent multiple contributing factors as mentioned in the above quote from Upton.

The risk estimates based on the Japanese ABCC data are suspect not only because atom bomb survivors are a select group—this should be self-evident—but because they are based on a comparison between survivors with low rates of low general mortality (or recipients of less than 10 rad) and high rates (or more heavily exposed groups). The assumption that cancers are equally easy to recognize in populations with high and low rates of general mortality is suspect because the immune surveillance mechanism normally holds in check all sources of foreign protein including small colonies of mutant cells (so called cancers *in situ*). Therefore, cancer promotion (or transition from cancer *in situ* to clinical cancer) is unlikely to occur unless there is loss of immunological competence which proceeds to have exactly the same effect on other much more acute diseases (for example, respiratory infections).

Such a change has been demonstrated in the ABCC data, that is, a year or more before these cancers developed to the point of being clinically recognizable the children were showing signs of being abnormally sensitive to infection (see G. W. Kneale and A. M. Stewart, "Pre-Cancer and Liability to Other Diseases," *British Journal of Cancer,* in print). Independently, it has been shown that the terminal phase of preleukemia is associated with a high risk of dying from pneumonia (see G. W. Kneale, "The Excess Sensitivity of Pre-Leukemics to Pneumonia: A Model Situation for Studying the Interaction of an Infectious Disease with Cancer," *British Journal of Preventive and Social Medicine,* 25 (1971), 152).

Therefore, it is probable that the proportion of unrecognized cancers (due to the long incubation period before cancer death) is positively correlated with the risk of any non-cancer deaths. Since, as pointed out

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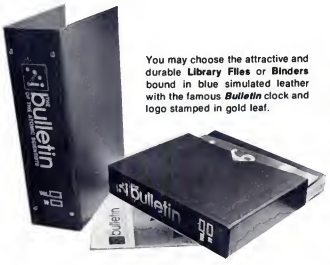

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above, the latency period of cancer development increases as the dose is decreased and the impaired reticuloendothelial system rather promptly removes members of the low exposure study group by infectious diseases, the Japanese ABCC data tend to underestimate the risk from low level exposure. Any suggestion from the ABCC data that there is a threshold dose below which there is no radiation induced cancer risk is an artifact caused by unrecognized cancers *in situ* that could not be identified in persons of early death resulting from infectious diseases that overtook death by malignancy.

There is no justification for Cohen's statement that the effects on the A-bomb survivors are generally about five times smaller than effects from medical exposures and that this "could be explained by the possibility that sick people (that is, those medically exposed) are more susceptible to cancer than the average." On the contrary, people with a disease that is serious enough to require treatment with radiation (for example, ankylosing spondylitis) have a *reduced* risk of living long enough to develop any cancer effects of the radiation. In the spondylitic survey the control group was taken from national statistics. Therefore, risk estimates based on those data tend to underestimate the cancer risk because they suffer from the same fault as those based on the ABCC data (that is, the control group should have been unirradiated persons who in the one case had ankylosing spondylitis and in the other persons exposed to the trauma associated with the fire and blast of the atomic bomb).

Cohen's statement that the average radiation worker receives only about 0.7 rem per year or a total of 30 rem over a 45-year career and that his cancer risk is only 0.4 percent or a loss of 20 days from his life expectancy is an understatement.

In the first place, there are thousands of individuals employed in nuclear power plants (station employees, utility employees, and temporary employees for "hot" jobs) who are receiving more than 0.7 rem per year. It is little consolation to the worker dying of a radiation induced cancer to know that the average employee received 1/7 his exposure. In the second place, Cohen probably used the ICRP coefficient of 1.25×10^{-4} fatal cancers per person-rem (that is, $30 \times 1.25 \times 10^{-4} = 0.4$ percent); but the total cancer risk given by ICRP is about twice this risk (who wishes to have his thyroids removed because of a non-fatal cancer?). The coefficient of 6×10^{-4} total cancers per person-rem which many persons are using would give a 1.8 percent risk of cancer. The cancer estimate using data from the Hanford study by Mancuso, Stewart and Kneale would be even higher.

Finally, Cohen has marked me as one of "those dedicated to the destruction of nuclear energy." With this I do not agree. For the past 35 years I, as a health physicist, have devoted most of my professional life to the study of risks from exposure to ionizing radiation and of ways in which this risk can be made acceptably small in comparison to the expected benefits. I believe it is those Don Quixotes who choose every opportunity to underestimate the radiation risk and to discredit those who carry out epidemiology studies of populations exposed to radiation risks who are the strongest supporters of the anti-nuke movements.

The paper by Mancuso, Stewart and Kneale indicated a 5 to 6 percent increase of dying of radiation induced cancer. We all have a 20 percent chance of leaving this life as a cancer patient, and perhaps increasing this risk to 25 percent could be considered acceptable in terms of the benefits—especially if other factors associated with employment at a place such as Hanford actually increased the overall life expectancy. □

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Joseph Rotblat's response: My impression at reading Bernard L. Cohen's criticism of my article in the September issue of the *Bulletin* is that he did not bother to read my article carefully before putting pen to paper. Many of the points he raised are either answered in my article or are irrelevant. Therefore, I shall limit my comments to a few items.

Cohen argues that my selection hypothesis of A-bomb survivors means that linearity grossly overestimates the effects of low doses. Actually it is the other way round. If we start from the assumption that for a normal population there is a linear relationship between cancer induction and dose, then the result of selection would be an apparent progressive reduction in the probability of cancer induction *per unit of dose* as we go from low to high exposure groups. Extrapolation from high doses would, therefore, underestimate the risk at low doses. Table 2 of my paper indeed shows this effect for cancers of the liver and lung among A-bomb survivors: the higher the dose the smaller the cancer rate per unit dose.

He goes on to say that my main argument is weak because "it is unique to Rotblat." This is a very odd attitude to take, as it implies the rejection of any original idea even if it is fully argued. I was, of course, aware of the various explanations of the difference in cancer incidence between A-bomb survivors and other irradiated populations which have been put forward in the literature, but their weakness is precisely that different explanations had to be given for each type of cancer and that it still leaves unexplained the absence of genetic effects or of increased overall mortality. My hypothesis explains *all* of the observed phenomena, and I would have thought that this alone would have made it a strong argument.

Cohen says that Karl Morgan and I have not given a very (*sic*) quantitative argument for reducing the ac-

cepted dose limits, and he proceeds to give his own estimates of the cancer hazards incurred by radiation workers as compared with risks in other industries. I cannot quite see why this should be better than the data which I have quoted from the ICRP (International Commission on Radiological Protection). According to ICRP, if a radiation worker receives the average dose of 0.5 rem per year, his life risk would be about the same as in an average safe industry, namely 10^{-4} deaths per year. I went on to argue that if the risk factors on which this estimate was based turned out to be too low, then the average radiation worker would run a higher risk than in other industries. All this is straightforward and simple, so why obfuscate the issue by throwing in some off-the-cuff estimates?

A figure for the cost to the nuclear industry of reducing the dose limits is quoted by Cohen. I am not an expert in the economics of nuclear power but it seems to me that his estimate of $500 million a year to reduce the limit by a factor of 10 (I suggested only a factor of 5) is unreasonably high. About half of the occupational exposure in the nuclear fuel cycle comes from reprocessing plants, but the total cost of reprocessing the fuel (about $165 per kilogram according to the American Physical Society) from nuclear reactors in the United States would come to only $200 million per year. But even on the basis of his estimate, and remembering that the cost of fuel is a small fraction of the electricity bill, a reduction of the dose limit by a factor of 5 would result in an increase of about 1 percent of the cost of electricity to the consumer. It seems to me that when presented in this way it would be acceptable by the community.

Which brings me to Cohen's last point, namely that the cost of saving the lives of a few radiation workers is unjustified since it is so much higher than the cost of reducing other hazards. I think this shows his lack of understanding of the way society works. Society does not attach the same price tag to every activity. Often enormous sums are spent to combat a rare disease, while more prevalent diseases are neglected. I believe that this emphasizes the instinctive abhorrence of society to express the value of human life in terms of dollars or pounds sterling. Every human life is invaluable, and the fact that certain hazards, like crossing the road or smoking cigarettes, claim numerous lives is no justification for allowing another hazard to continue, if something can be done about it, even if it would result in a much smaller number of victims. All this brings to my mind Oscar Wilde's definition of a cynic: "A man who knows the price of everything and the value of nothing."□

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Human Rights

Let me resonate wholeheartedly with Mark Mellman's comments (*Bulletin*, November 1978) on my article on "Human Rights and the Polity of Science" in the previous issue of the *Bulletin*. We are almost exactly on the same wave length in our concerns and in the policy considerations that would follow from them.

But Mellman, like many other scientists, is a little reluctant to align himself precisely with the international code of human rights. This attitude is puzzling, for he does not put forward really persuasive arguments to back his objections to such a policy. Perhaps the clue to his attitude lies deeper than mere argument. He uses phrases such as "not get trapped in legalisms" and "codification of the value allocation decisions made through the political process" which subtly denigrate both law and politics. The suggestion that we "look somewhat closer to home and find similar expressions to the human rights code in resolutions of the International Council of Scientific Unions" implies that science is somehow better than other callings and social institutions at this sort of thing.

This confidence in the nobility, humanity, rationality and other virtues of science is not, of course, meant arrogantly. But it embodies a misconception which is very damaging in the present context. On the one hand, it binds the scientific community to the wisdom and experience that lawyers, politicians, moral philosophers, and others have already acquired in the definition and protection of human rights. It is pathetic to see the learned societies and their leaders slowly rediscovering the basic principles of freedom and responsibility, and grappling amateurishly with ambivalences of definition and action that have long been familiar in more *political* circles. Years of effort are being wasted as we painfully find *our* way toward goals that are fully shared, and energetically sought by our fellow citizens in the free world.

On the other hand, by the mere suggestion that science deserves its own special code of rights, we are claiming an elite status that may alienate those same fellow citizens from this common cause. I entirely agree with Mellman that the human rights code is inadequate as a complete protection of individual rights against the tyranny of State power—but that is as much a matter of concern for the poet, the lawyer, or the minister of religion as for the nuclear physicist.

What astonished me when I came to study the various declarations and covenants was the completeness with which the wording of the code does in fact cover the needs of science, however imperfect may be this protection in practice. Our aim, then, surely, must be to ally ourselves with all organizations and persons of good will in getting this code established according to the direct meaning of its own words, for scientists and all others.□

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DONALD R. WESTERVELT

Can cold logic replace cold feet?

In the November 1978 *Bulletin*, William H. Kincade reports that "cold feet" have developed in the Carter administration on the comprehensive test ban treaty (CTB). In a four-prong article, Kincade (1) speculates on possible reasons for the President's mid-June change in course, (2) defends the thesis that "On technical grounds . . . the case for concluding a CTB treaty was never stronger," (3) presents arguments for the political feasibility/desirability of a CTB at this time, and (4) analyzes the Administration's "failure" to clinch such a treaty while the iron was hot. Of these only the first and second will be of concern here. Certain factual matters require further discussion if the third and fourth of Kincade's subjects are to be placed in reasonable perspective.

It is known that the "reining-in" of the CTB negotiations occurred directly on the heels of a briefing of Mr. Carter and a few top advisers by Harold M. Agnew and Roger Batzel, the weapons-lab directors. The briefing reportedly was scheduled for 15 minutes but ran 90. It seems most plausible that the action of the President following that meeting is adequately explained as a logical result of new information presented, facts of which he may previously have been unaware. Kincade describes the President as "surrounded by advisers inexperienced in the issues," a benign explanation. In any case, it seems unnecessary to invoke what amounts to a conspiracy theory involving CTB opponents and other hard-liners (including "threshold proponents," as he is kind enough to identify this writer) to rationalize the reported change in position. Facts carry their own imperatives.

Since it may well have been technical facts that influenced the June decisions, it seems appropriate in this short note to turn immediately to certain matters relating to point (2) above (without any intended implication that the same information influenced the President). Three such matters will be discussed, in ascending order of importance: verification; the role of stockpile proof-tests in particular; and the role of testing in general in maintaining confidence in the reliability of U.S. deterrent force, especially as it leads to the discovery of stockpile problems unrevealed by other means.

Editor's note: For those of us who have been involved from the beginning (way back in the late 1950s) in the efforts for a Comprehensive Nuclear Test Ban, the current disagreements between experts cannot help but inspire a feeling of *déjà vu*. It should be clear by now that the relevance of possible cheating and the importance of proof-testing are essentially political, not technical issues. Of one thing one can be quite sure: our weapons experts are not technically so uninspired as to be unable to think of ways of proof-testing weapons components without actually producing a nuclear explosion. In this, as in so many other arms control issues, where you come out depends primarily on where you came in.

According to Kincade, "All seismic events . . . can be identified down to the level of three-to-five kiloton yields, or perhaps below." Deployment of "black boxes" on Soviet and American soil, he alleges, "would permit identification of seismic events even below the three-to-five kiloton level . . . permitting protection against any meaningful evasion scenario . . . ." Analysis of unclassified sources, however, raises serious doubts about the validity of these statements and leads to troublesome questions about the relative effects of a CTB (of more than a few years duration) on American and Soviet forces.[1]

The verification problem was outlined in March 1978 testimony by Carl Romney,[2] who explained that " . . . we would expect to record . . . several score natural events per year, earthquakes, which we would not be able to say with assurance were not explosions. And if we did detect an explosion, it would be mixed in among that population. So from a seismic standpoint, you are faced with a difficult problem of trying to pick out one of those events and claim a violation." In question are so-called "ambiguous events," which remain unidentified as natural or man-made after all seismic criteria have been exhausted (a fraction of these can be eliminated by non-seismic means, but the majority remain ambiguous). Their numbers increase rapidly as the magnitude of their seismic signature decreases, corresponding to lower and lower explosive yields if the source is, in fact, an explosion rather than an earthquake.

Earlier testimony by Romney, in 1963 and 1971,[3] provides a basis for analysis leading to estimates of the ambiguous event populations at seismic magnitudes corresponding to a range of nuclear yields. Only the conclusions will be summarized here; the details are available: If explosions of three kilotons were carried out in a soft material such as dry alluvium, their signals would be mixed among an average yearly population of around 500 ambiguous events of similar or larger magnitudes. Five kiloton tests would fall among 200 such events, and even at 10 kilotons

the number would be about 60 per year. These are averages subject to natural fluctuations, and I estimate that one year in two the populations listed may be expected to vary up or down by at least the following amounts: at three kilotons, 15 per year; at 5 kilotons, 9 per year; and at 10 kilotons, 5 per year. (Fluctuations twice as large should happen once in five years.)

Suitable media exist in the Soviet landmass to permit tests at these yields without fear of collapse-crater formation, and the 1963 Romney testimony permits one to conclude that the numbers given above would be little changed by the presence on Soviet soil of reasonable numbers of black boxes (monitors). Thus CTB verification at 3 to 5 kilotons or even lower does not seem possible. (The same conclusion cannot be reached for tests at somewhat higher yields, where Romney's testimony suggests that black boxes might be of considerable value.) In fact, it is becoming clear that there is no single "verification threshold" in terms of an explosive yield above which a Soviet violator would not dare to attempt a clandestine test and below which he can test at any rate he chooses. Instead, we can see that the frequency with which he can test is a function of the yield at which he may feel the need to test (to solve a stockpile problem, perhaps), and at yields of 3 to 5 kilotons that frequency can be quite high.

Compliance issues are not likely to be raised over observed fluctuations in event populations that can normally be expected one year in two. Further, at the relatively low (but important) yields discussed here, with the consequent absence of definitive seismic evidence as to source and location, the value of on-site inspections as a verification measure would seem marginal. (They may, of course, have some deterrent value at low yields and actually contribute to verification at levels where the ambiguous-event population is small).

In sum, the Kincade assertions about verification do not ring true. This is one of several reasons for my advocacy (with certain qualifications) of an appropriate threshold, which would appear to be one at which the ambiguous-event population is small, that is, something more than 10 kilotons. Reduction of the present (unratified) 150-kiloton threshold by a factor of ~5 might be the most reasonable next step in limiting testing.

On this point Sidney Drell of the Stanford Linear Accelerator Center says: "Proof-testing is not necessary to maintain the reliability of the deterrent. In fact it is one of the least often used methods in the U.S. program . . . ." True, but beside the point. Weapons are seldom removed from the stockpile and fired to show that they work, for good reason. There is an important synergism among *all* of the tests that are done, but most important for maintaining confidence in the reliability of the stockpile are the substantial numbers of nuclear tests that involve either key components (for reliability) of the stockpile weapons, or weapons themselves.

These latter tests are not, in general, performed because of immediate concerns about weapon reliability; instead, they serve other purposes. But in conjunction with the primary purpose of such tests, they also confirm that the weapon or component involved functions properly. For Los Alamos weapons in stockpile there have been at least 89 instances where tests with other main objectives also confirmed the performance of those weapons or components. Thus, in the normal course of events a large data base has been accumulated about weapons in the stockpile. No data base like that which now exists would develop for scheduled new weapons, if all tests stopped for an indefinite period. It would entail years of costly research to investigate the feasibility of long-term stockpile maintenance without any testing, and the outcome of that research is very uncertain. It is against this background that the alleged rarity of "stockpile proof-tests," narrowly defined, must be evaluated.

Kincade states that "Experience has shown . . . that the reliability of the stockpile can be maintained without nuclear testing." By this he means not only without proof-testing, but without any nuclear testing at all. Yet the only relevant experience, that of the 1958-61 moratorium, showed just the opposite. Only the 1961-62 resumption of testing allowed us to fix important problems found or suspected during the freeze. Also, and crucially important in looking ahead, is the fact that it was only the resumption of full-scale research and development testing that led to the discovery of by far the most significant stockpile problems. This discovery process will be needed, together with knowledgeable, experienced people, so long as nuclear weapons exist.

Here a single example must suffice. Kincade notes the importance of the reliability of the low-yield fission triggers of thermonuclear weapons.[4] Reliable they must be, but they must also be small, safe and highly efficient, largely because of the constraints imposed by modest U.S. delivery systems. One way to attain high efficiency in any fission device involves the process called "boosting," defined as the enhancement of a

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fission reaction by thermonuclear neutrons where the energy released by the thermonuclear reaction is a small fraction of the total. The hydrogen isotope tritium is used in boosting, but the performance of boosting fuels containing tritium is degraded in time by its radioactive decay to ^3He (half-life, 12 years). Thus the performance of the fuel, and by implication the fission reaction, can be expected to change adversely in periods of time measured in years rather than in decades.

The effects of loss of tritium and/or buildup of ^3He were thought to be understood and calculable prior to the moratorium, and all fission device tests in which boosting was a factor were then performed at "zero years," that is, with no ^3He present and zero-year quantities of tritium. Only some time after post-moratorium testing resumed did the predictability of aging effects come sufficiently into question to justify a nuclear test to check the point. The test showed that these effects had been so severely underestimated that a cloud of then unknown proportions immediately fell over many of our weapons. At the time, the only way to resolve each specific case was to conduct the appropriate nuclear test of the weapon, at the scheduled maximum age of its limited-lifetime components. Necessary decisions or adjustments for affected systems were made as a result of these tests, and confidence was restored.

Lessons from this experience were

- that the problem most probably would not have been found had the moratorium not ended;
- if it had been seriously suspected (unlikely in the circumstances), abrogation of the moratorium to solve it would have been virtually imperative although the needed tests were all small); and,
- in their technical innocence, under a continued moratorium the laboratories would have found it easy to acquiesce in economically-justified requests from the services to extend the stockpile lifetimes of the components in question.

In certain cases this would have been safe, but in others it could have led to premature and catastrophic failure of certain stockpile weapons near the end of their "expected" life, even though weapons of that era were considered "forgiving" relative to their more modern counterparts. Tests at end-of-component life are routine today because of the conclusion forced upon weapon designers by nuclear test results—that boosted fission-device design remains largely an empirical science.

This single but illustrative example may help explain recent weapon laboratory positions on the test-ban issue.

In March 1978, when the Carter administration was still proposing a CTB treaty of *unlimited* duration, a Department of Energy witness supported adequately verifiable and symmetrical arms control agreements but testified also that without some continued nuclear testing, at low but sufficient yields, the laboratories would eventually be unable to certify new or rebuilt weapons for the stockpile, and that "we could not maintain the same confidence in our nuclear weapons stockpile that we have today, based on test experience."[1]

In August 1978, when a treaty of *limited* duration had become the subject of hearings (Kincade speaks of three years with very low-yield experiments during the treaty), the same witness testified that the nation's nuclear stockpile and capability could be maintained at low risk for a short time, without testing at the yields mentioned in the context of the indefinite-duration treaty, "provided we pursued a vigorous safeguards program during the period of the ban *and resumed testing on the expiration of a treaty.*"[2] (Emphasis added.) In this context, of course, the ultimate safeguard is the commitment to resumption of testing at treaty's end. Without that commitment any other "safeguards" would, in my view, be of dubious value.[3]

Fred C. Iklé, in the August 1978 hearing,[4] testified in favor of a low but verifiable threshold treaty that could last indefinitely, as against a "zero-yield" treaty almost certain to end after a brief hiatus in test activity. An alternative not discussed by Iklé would be the case in which a short "zero-yield" treaty might be followed by more or less permanent low threshold. I have already suggested what that threshold might logically be. The facts presented here may not have been available to Kincade, but in their light a certain application of cold logic might well allow the Administration to recover from its attack of cold feet and save the day.□

1. Donald R. Westervelt, "Candor, Compromise, and the Comprehensive Test ban," *Strategic Review*, 4 (Fall 1977), 33-44. The present discussion should be read in context with this earlier effort to explain the CTB problem.

2. "Current Negotiations on the Comprehensive Test Ban Treaty," Hearings before the Intelligence and Military Application of Nuclear Energy Subcommittee of the Committee on Armed Services, House of Representatives, 95th Congress (March 15-16, 1978). Dr. Romney is director of the Defense Advanced Research Project Agency's Nuclear Monitoring Research Office.

3. "Developments in Technical Capabilities for Detecting and Identifying Nuclear Weapons Tests," Hearings before the Joint Committee on Atomic Energy, 88th Congress (March 5-8, 11-12, 1963); "Status of Current Technology to Identify Seismic Events as Natural or Man Made," Hearings before the Subcommittee on Research, Development, and Radiation of the Joint Committee on Atomic Energy, 92nd Congress (Oct. 27-28, 1971).

4. For an introduction to thermonuclear weapons see Edward Teller, "Hydrogen Bomb," *Encyclopedia Americana*, 654-66.

5. Romney, "Current Negotiations," p. 22.

6. "Effects of a Comprehensive Test Ban Treaty on United States National Security Interests," Hearings before the Panel on the Strategic Arms Limitation Talks and the Comprehensive Test Ban Treaty of the Intelligence and Military Application of Nuclear Energy Subcommittee of the Committee on Armed Services, House of Representatives, 95th Congress (Aug. 14-15, 1978), 8. See also p. 175.

7. Donald R. Westervelt, "The Safeguards Smokescreen," *Defense and Foreign Affairs Daily*, September 19-20, 1977.

8. Committee Hearings, Aug. 14-15 1978, pp. 135 and following.

DAVID N. SCHWARTZ

Salty debate in the Senate

The Senate debate over the SALT II package promises to be unsurpassed in high drama. The stakes involved alone will be enough to assure this. Not only does the SALT process affect some of the most deeply troubling security concerns of our era; upon it also hinges the ability of our government to conduct a coherent foreign policy reflecting U.S. national objectives.* Some have likened it to the debate over the Treaty of Versailles in 1919; while this may turn out to be an exaggeration, it is certainly no exaggeration to predict that it will be historic.

As Michael Mandelbaum correctly notes, there are legitimate reasons for adopting the emerging agreements solely on national security grounds. By placing ceilings on a whole range of Soviet strategic systems, SALT II will reduce our uncertainties about the evolving Soviet strategic threat. While any ceilings would do this, these ceilings are particularly attractive, since they are set at levels lower than the Soviets would be capable of deploying without the agreements. As many administration officials have confirmed, SALT II will require the Soviets to dismantle some two to three hundred strategic nuclear launcher vehicles. In contrast, the United States will be permitted to continue its on-going strategic programs without interruption.

There is danger in overemphasizing the security SALT II will buy for us. It will not solve the Minuteman vulnerability problem—if indeed one considers it a problem worth solving—but no politically feasible agreement could do so without creating untenable verification problems. Nevertheless, Minuteman vulnerability is perceived as a problem, and no SALT agreement which prevents us from dealing with it unilaterally is likely to be acceptable to the Senate. Significantly, the SALT II agreements appear to permit us to move in any one of a number of directions to rectify this situation.

In addition, SALT II will probably neither reduce the likelihood of nuclear war, nor the catastrophe that might occur should strategic nuclear deterrence fail. In order to argue that SALT reduces the probability of nuclear war, we would have to know the dynamics of how nuclear wars occur. There being no empirical data to support such an argument (Thank God!), and no truly plausible model of how deterrence would fail or what would happen once it did, there can hardly be grounds for confidence in this respect. Certainly if nuclear war does occur between the United States and the Soviet Union, the high levels of weaponry permitted to each country under SALT II give no outcome less than mutual suicide.

But modest as it may seem, the incremental security we do buy when we place certain important constraints on the future Soviet strategic threat is well worth the effort of the SALT process. It will allow us to plan more effectively, and less wastefully. The element of reduced uncertainty has psychological as well as military benefits for both countries. Perhaps the most important of these is that it reduces the chance that, through an unforeseen development in one country, the other country will be impelled into a dangerous and potentially destabilizing overreaction. Because of SALT, it is less likely that a new and inexperienced Soviet leadership, taking over when Brezhnev departs from the scene, will panic in the face of on-going U.S. strategic programs.

The military aspect of SALT is not the entire story. By bringing the two superpowers together on a regular basis to discuss the most fundamental aspects of their respective security problems, it contributes to a policy of preventing American-Soviet relations from dangerously deteriorating. Here the payoffs are largely psychological, but nevertheless real. A breakdown in the talks could signal the beginning of a dramatic rift.

One of the fortunate aspects of the impending SALT II debate is that it will probably focus most directly on these issues. As Flanagan points out, one of the results of bringing the Senate into the negotiation process, in the admittedly limited manner he describes, is that many senators are now personally familiar with a wide range of sophisticated and complex strategic issues and problems. This education process will undoubtedly have a positive effect on the level of debate in the Senate chamber. Thus, much of the debate will probably focus on the kinds of security issues raised above: the emerging Soviet threat, the likelihood of nuclear war, etc. Other issues which will probably figure heavily in the debate are:

- *The American-Soviet strategic balance.* Will SALT II preserve "essential equivalence" in the strategic balance? Or will it promote Soviet strategic superiority? If the debate is to clarify these questions, it will have to emphasize that simple numerical comparisons have little military significance and thus should have little political significance; that more complex dynamic analyses, examining system performance in plausible strategic scenarios, are far more helpful in assessing the balance; and that the SALT II provisions are not likely to allow the current

*See Stephen J. Flanagan, "The new politics of arms control: Congress, the White House and SALT," *Bulletin*, November 1978; and Michael Mandelbaum, In Defense of SALT," *Bulletin*, January 1979.

situation—essential equivalence—to deterioriate.

• *the verification issue.* Will SALT II be verifiable? Can we trust the Russians to keep their end of the bargain? The answers to these questions will be critical to the success of the Admministration's efforts for ratification. The debate will be most fruitful if it recognizes that no agreement can ever be perfectly verifiable; that the important criterion for measuring verifiability is whether one could be highly confident of detecting strategically significant cheating; and that our national technical means of verification, including advanced photo-reconaissance satellites, will allow us to verify the agreements as a whole to this acceptable standard.

• *the general American-Soviet relationship.* Does SALT continue to represent a way of promoting détente? Or does it reflect a naiveté about true malevolent Soviet intentions? Furthermore, can SALT ratification be withheld in order to influence successfully other aspects of Soviet behavior we find distressing, such as its African adventures and its repression of internal political dissidents?

It will be unfortunate if the debate paints a picture of American-Soviet relations that is too black and white. One way to avoid this tendency would be to recognize at the outset that the relationship will remain a complex combination of conflict and cooperation for the foreseeable future. While we must protect our interests where they conflict with those of the Soviet Union, we must also recognize that in certain policy areas, such as strategic nuclear security, there are legitimate benefits to be derived from cooperation. Pretending that SALT is somehow a favor we are doing for the Russians, one that we can withhold when they behave like bad boys, is at once to ignore the security benefits *we* derive from the agreements and at the same time to pursue an ultimately ineffectual effort at policy linkage.

While it would be foolhardy to predict how the Senate debate will turn out, there is every indication that these will be the central issues. One of the main differences anticipated between the SALT I and SALT II debates is that now many more senators will feel comfortable discussing these intricate questions of national security and foreign policy. Those who favor ratification of the emerging agreements will face a difficult task. But if the debate addresses the crucial questions, and demonstrates a high level of intellectual and political integrity, it will not be an impossible task.□

David N. Schwartz, who currently is a doctoral candidate at MIT, *was an advisor to Sen. Gary Hart on* SALT *from June to October 1978.*

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The MX in Kansas!

Dear President Carter:

With growing outrage, I recently reviewed the potential impact of the proposed MX mobile missile system on the state of Kansas. To make you aware of the gravity of the matter, I must recite some of the most unbelievable potential impacts of this system:

• disruption of up to 186,000 acres of western Kansas farm and range land by road building, excavation, dumping of excess earth, construction of support facilities and other activities;

• depletion of groundwater reserves and lowering of the water table in many of the potential siting areas;

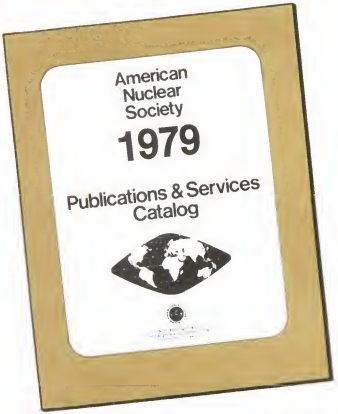
• exclusion of people for security purposes from an area as large as 6,500 square miles—an area the size of eight western Kansas counties with a population of nearly 40,000 Kansans;

• suspension of existing uses of land in areas as large as 4 million acres for purposes such as farming, recreation, grazing and human inhabitation for the life of the project; and

• energy requirements of up to 840 gigawatt-hours per year—an energy demand roughly equivalent to the electrical consumption of a city of 50,000 people and likely to require the construction of new power-generating facilities.

Mr. President, in plain English, the U.S. Air Force is proposing that potentially 8 percent of the entire state of Kansas be removed from civilization, from the citizens of our state and from their productive use of this land for a period of at least 20 to 30 years. I find this proposal unbelievable and inconceivable. I urge you and the Air Force to immediately suspend any further consideration of sites in the state of Kansas for the mobile missile program as envisioned in the report.

GOVERNOR ROBERT F. BENNETT
State of Kansas



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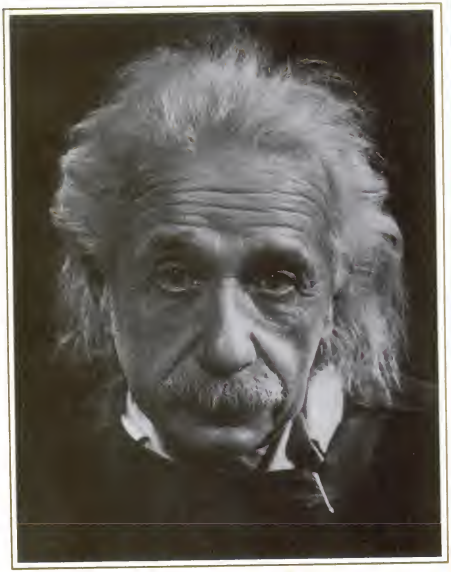
March 1979 marks the 100th anniversary of the birth of Albert Einstein, a founding sponsor of the *Bulletin*. To commemorate the event, the Bulletin will publish a special issue in his honor. The contributors are: Bernard T. Feld, Harrison Brown, Glenn Seaborg, Joseph Rotblat, Hannes Alfven, Margaret Gowing, Spencer Weart as well as recollections by Eugene Rabinowitch, James Franck, Leo Szilard and Robert Oppenheimer.



Einstein and Peace

PLUS
an exchange of letters on peace between Alva Myrdal, author of *The Game of Disarmament*, and Toshiyuki Toyoda, professor of physics at Nagoya University and convener of the Japanese Pugwash Committee.

"*The real ailment seems to me to lie in the belief that we must in peacetime so organize our whole life and work that in the event of war we would be sure of victory. This attitude gives rise to the belief that one's freedom and indeed one's existence are threatened by powerful enemies.*" —Albert Einstein on "Symptoms of Cultural Decay," *Bulletin*, October 1952.

"*Even now, some 40 years later, the importance of Einstein's role in the American achievement of nuclear weapons before the end of the war against Japan, remains a source of legitimate controversy.*" —Bernard Feld in "Einstein and the Politics of Nuclear Weapons."

"*From the first time I heard him speak, I could only think of his deep concern for humanity. In this respect, his face—and particularly his eyes—were fully as eloquent as his words.*"—Harrison Brown in "An Early Brief Encounter."